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Description

Background

- 5 **[0001]** This patent relates to conversion of carbon dioxide into methane using electrical energy, which conversion may also create or generate byproducts, such as carbon credits or oxygen, for example.
- [0002]** The US annually consumes about 90 ExaJoules (EJ) of carbon-based fuels, 88% of its total energy consumption in 2008. The use of these fuels is supported by heavily capitalized processing, distribution and utilization industries.
- 10 **[0003]** The sustainability of these systems is questionable on two counts. First, the US imports 25% of the energy it uses, a proportion that is projected to increase substantially. Imported energy is obtained from sources that are under pressure to serve increasing demand from growing economies in other parts of the world. Second, more than 96% of the carbon-based fuels are obtained from fossil reserves, which are finite. Useful energy is obtained from carbon-based fuels by oxidizing reduced states of carbon to carbon dioxide. For fossil fuels, this process is basically open-loop, producing CO₂ with no compensating carbon reduction process to close the cycle. The consequent gradual accumulation
- 15 of atmospheric CO₂ is beginning to cause changes in the global climate that threaten many aspects of our way of life. Therefore, a process that can close this carbon energy cycle for the total energy economy is needed.
- [0004]** An annual flux of 58,000 EJ of solar energy strikes US soil, making it our most abundant carbon-free energy resource - 500 times current consumption. Solar energy has the unique advantage of being a domestic resource not just in the US, but everywhere that people live. Its widespread use as a primary resource would secure energy inde-
- 20 pendence throughout the world. Nevertheless, today solar energy is only a marginal component of the energy economy, providing less than 0.1% of marketed US energy consumption. Exploitation of solar energy is limited principally because it is intermittent and cannot be relied upon to provide the base-load energy that must be available whenever needed. What is lacking is a method for storing solar energy in a stable form that can be tapped whenever needed. Ideally, such a storage form should fit smoothly into the existing energy infrastructure so that it can be quickly deployed once developed.
- 25 **[0005]** There is a need in the energy industry for systems to convert one form of energy into another. In particular, there is a need for systems to convert electricity into a form of energy that can be stored inexpensively on industrial scales. Many sources of electricity generation cannot be adjusted to match changing demand. For example, coal power plants run most efficiently when maintained at a constant rate and cannot be adjusted as easily as natural gas (methane) fired power plants. Likewise, wind turbines generate electricity when the wind is blowing which may not necessarily
- 30 happen when electricity demand is highest.
- [0006]** There is also a need to convert electricity into a form that can be transported long distances without significant losses. Many opportunities for wind farms, geothermal, hydroelectric or solar based power generation facilities are not located close to major population centers, but electric power losses over hundreds of miles add significant cost to such distant power facilities.
- 35 **[0007]** Methane is one of the most versatile forms of energy and can be stored easily. There already exists much infrastructure for transporting and distributing methane as well as infrastructure for converting methane into electricity and for powering vehicles. Methane also has the highest energy density per carbon atom of all fossil fuels, and therefore of all fossil fuels, methane releases the least carbon dioxide per unit energy when burned. Hence, systems for converting electricity into methane would be highly useful and valuable in all energy generation and utilization industries.
- 40 **[0008]** In principle, it would be possible to produce methane from electric power in a two-step process, such as outlined schematically in Fig. 1. The first step would use the electric power to make hydrogen gas from water in a standard water electrolysis system 50. In a second step, the hydrogen gas could then be pumped into a methanogenic reaction chamber 52 such as a highly specific biological reactor of methanogenic microbes. One such biological reactor is described in U.S. patent application 12/333,932 by Laurens Mets. WO 2002075022 relates to methods using neutral red to mediate
- 45 the interconversion of chemical and electrical energy.

Summary

- 50 **[0009]** The present disclosure describes a system to convert electric power into methane including a biological reactor having at least a first chamber containing at least a cathode, a culture comprising methanogenic microorganisms, and water, and a second chamber containing at least an anode. The biological reactor has an operating state wherein the culture is maintained at a temperature above 50 °C. The system also includes a source of electricity coupled to the anode and the cathode, a supply of carbon dioxide coupled to the first chamber, and an outlet to receive methane from the first chamber.
- 55 **[0010]** The present invention is directed to a method for producing methane, the method comprising:
- (a) supplying electricity to an anode and a porous electrically conductive cathode of a biological reactor, wherein the biological reactor

(i) is coupled to a source of electricity and a source of carbon dioxide,
(ii) has at least a first chamber containing at least the cathode, a culture comprising methanogenic microorganisms, and water, a second chamber containing at least the anode, and a proton permeable, gas impermeable barrier separating the anode from the cathode, and
5 (iii) has a current collector coupled to each of the anode and the cathode, wherein the cathode is impregnated with the methanogenic microorganisms and with an aqueous electrolytic medium,
wherein the methanogenic microorganisms are in a passage formed between the barrier and the current collector coupled to the cathode and located between an inlet for carbon dioxide and an outlet for methane,
10 wherein the culture is maintained in the aqueous electrolytic medium in the passage of the first chamber at a temperature above 50 °C;

(b) supplying carbon dioxide to the first chamber through the inlet of the first chamber, whereupon the carbon dioxide is dissolved into the aqueous electrolytic medium;

(c) circulating the aqueous electrolytic medium comprising the dissolved carbon dioxide through the cathode; and

15 (d) collecting methane from the outlet of the first chamber.

According to another aspect of the present disclosure, a method of converting electricity into methane includes supplying electricity to an anode and a cathode of biological reactor having at least a first chamber containing at least the cathode, a culture comprising methanogenic microorganisms, and water, and a second chamber containing at least the anode, the biological reactor having an operating state, wherein the culture is maintained at a temperature above 50 °C. The method also includes supplying carbon dioxide to the first chamber, and collecting methane from the first chamber.

25 **[0011]** According to a further aspect of the present disclosure, a method of creating carbon credits includes supplying electricity to an anode and a cathode of biological reactor having at least a first chamber containing at least the cathode, a culture comprising methanogenic microorganisms, and water, and a second chamber containing at least the anode, the biological reactor having an operating state wherein the culture is maintained at a temperature about 50 °C. The method also includes supplying carbon dioxide to the first chamber, and receiving carbon credits for the carbon dioxide converted in the biological reactor into methane.

30 Brief Description of the Drawings

35 **[0012]** It is believed that the disclosure will be more fully understood from the following description taken in conjunction with the accompanying drawings. Some of the figures may have been simplified by the omission of selected elements for the purpose of more clearly showing other elements. Such omissions of elements in some figures are not necessarily indicative of the presence or absence of particular elements in any of the exemplary embodiments, except as may be explicitly delineated in the corresponding written description. None of the drawings is necessarily to scale.

Fig. 1 is a schematic view of a system for converting carbon dioxide into methane according to the prior art;

Fig. 2 is a schematic view of a system for converting carbon dioxide into methane according to the present disclosure;

40 Fig. 3 is a cross-sectional view of a reference example of a biological reactor for converting carbon dioxide into methane;

Fig. 4 is a cross-sectional view of an embodiment of a biological reactor for converting carbon dioxide into methane;

Fig. 5 is a cross-sectional view of yet another embodiment of a biological reactor for converting carbon dioxide into methane;

45 Fig. 6 is a cross-sectional view of a further embodiment of a biological reactor for converting carbon dioxide into methane;

Fig. 7 is a schematic view of an embodiment of a biological reactor with a plurality anodes and cathodes;

Fig. 8 is a cross-sectional view of the system of Fig. 7 taken along line 8-8;

Fig. 9 is a cross-sectional view of one of the plurality of biological reactors of Fig. 8 taken along line 9-9;

50 Fig. 10 is a cross-sectional view of a variant biological reactor for use in the system of Fig. 7;

Fig. 11 is a schematic view of a series arrangement of biological reactors according to the present disclosure;

Fig. 12 is a schematic view of a parallel arrangement of biological reactors according to the present disclosure;

Fig. 13 is a schematic view of a stand-alone system according to the present disclosure;

Fig. 14 is a schematic view of an integrated system according to the present disclosure; and

55 Fig. 15 is a graph of methane production over time with varying voltage applied across the anode and cathode of a biological reactor according to Fig. 3.

Detailed Description of Various Embodiments

[0013] Although the following text sets forth a detailed description of numerous different embodiments and reference examples, it should be understood that the legal scope of the invention is defined by the words of the claims set forth at the end of this patent.

[0014] It should also be understood that, unless a term is expressly defined in this patent using the sentence "As used herein, the term '_____' is hereby defined to mean..." or a similar sentence, there is no intent to limit the meaning of that term, either expressly or by implication, beyond its plain or ordinary meaning, and such term should not be interpreted to be limited in scope based on any statement made in any section of this patent (other than the language of the claims). To the extent that any term recited in the claims at the end of this patent is referred to in this patent in a manner consistent with a single meaning, that is done for sake of clarity only so as to not confuse the reader, and it is not intended that such claim term be limited, by implication or otherwise, to that single meaning.

[0015] The present disclosure addresses the processing or conversion of carbon dioxide into methane using an electro-biological apparatus. The apparatus may be referred to herein as a biological reactor, bioreactor, processor, converter or generator. It will be recognized that this designation is not intended to limit the role that the converter may perform within a system including one or more converters.

[0016] For example, the apparatus provides a non-fossil carbon-based energy resource. In this regard, the apparatus is being used to generate an energy resource that may be substituted for fossil-based carbon fuels, to reduce reliance on fossil-based carbon fuels, for example. Additionally, the apparatus converts or processes carbon dioxide to generate this energy resource. In this regard, the apparatus removes carbon dioxide from the environment, which may be a beneficial activity in and of itself. Such removal of carbon dioxide from the environment may happen by removing carbon dioxide directly from the atmosphere or by utilizing carbon dioxide from another industrial process and thereby preventing such carbon dioxide from being released into the atmosphere or into a storage system or into another process. Further, the apparatus converts or processes carbon dioxide into methane using electricity to convert electricity into another energy resource when demand for electricity may be such that the electricity would otherwise be wasted or even sold at a loss to the electricity producer, for example. In this regard, the apparatus may be viewed as part of an energy storage system. In the operation of a power grid, or an individual power plant or other power source on the grid, or as part of a facility not associated with a power grid, or in the operation of a biological reactor, available power output may be used by one or more biological reactors to consume as an input carbon dioxide, water or electrical power and to produce methane or oxygen when business conditions are favorable to provide an incentive greater than for other use of such inputs. Such conditions may exist when certain regulatory policies, power purchase agreements, carbon credits, futures trading opportunities, storage capacity, electrical demand, taxes, tax credits or abatements, contracts, customer preferences, transmission capacity, pricing conditions, or other market incentives can provide sufficient value for operation of the biological reactor to produce methane or oxygen or to consume carbon dioxide, water or electrical power. In addition to the above and other uses, the apparatus converts electrical energy or power into methane which may be transmitted via natural gas transmission pipes which on a per unit energy basis are less expensive than electrical transmission lines and in some locales the electrical transmission lines may not have as much spare transmission capacity as the natural gas transmission lines. In this regard, the apparatus may be viewed as part of an energy transmission system. All of these roles may be performed by an apparatus according to the present disclosure.

[0017] As illustrated in Fig. 2, the biological reactor according to the present disclosure may include a container that is divided into at least a first chamber and a second chamber. At least one cathode is disposed in the first chamber, and at least one anode is disposed in the second chamber. The first chamber has inlets that are connected to a source of carbon dioxide gas and a source of water, and an outlet that is connected, for example, to a storage device used to store methane produced in the first chamber. The first and second chambers are separated by a divider that is permeable to ions (protons) to permit them to move from the second chamber to the first chamber. This membrane is impermeable to the gaseous products and by-products of the conversion process to limit or prevent them from moving between the first chamber and the second chamber.

I. Description of System and Biological Reactor

[0018] Methanogenic microorganisms may be cultured, for example, in shake or stirred tank bioreactors, hollow fiber bioreactors, or fluidized bed bioreactors, and operated in a batch, fed batch, continuous, semi-continuous, or perfusion mode. In batch mode (single batch), an initial amount of medium containing nutrients necessary for growth is added to the biological reactor, and the biological reactor is operated until the number of viable cells rises to a steady-state maximum, or stationary condition. In fed-batch mode, concentrated media or selected amounts of single nutrients are added at fixed intervals to the culture. Methanogenic microorganisms can survive for years under fed batch conditions, provided that any waste products are effectively minimized or removed to prevent loss of efficiency of methane production over time. Any inhibitory waste products may be removed by continuous perfusion production processes, well known in

the art. Perfusion processes may involve simple dilution by continuous feeding of fresh medium into the culture, while the same volume is continuously withdrawn from the reactor. Perfusion processes may also involve continuous, selective removal of medium by centrifugation while cells are retained in the culture or by selective removal of toxic components by dialysis, adsorption, electrophoresis, or other methods. Continuously perfused cultures may be maintained for weeks, months or years.

[0019] Fig. 3 illustrates a reference example of a system 100 that may be used, for example, to convert electric power into methane. The system 100 includes a biological reactor 102 having at least a first chamber 104 and a second chamber 106. The first chamber 104 may contain at least a cathode 108, a culture comprising living methanogenic microorganisms, and water. In particular, the culture may comprise autotrophic and/or hydrogenotrophic methanogenic archaea, and the water may be part of an aqueous electrolytic medium compatible with the living microorganisms. The second chamber may contain at least an anode 110.

[0020] The biological reactor 102 may also include a selectively permeable barrier 112, which may be a proton permeable barrier, separating the anode 110 from the cathode 108. The barrier 112 may be at least gas semipermeable (e.g., certain gases may pass through, while others are limited), although according to certain reference examples, the barrier 112 is impermeable to gases. According to certain reference examples, the barrier 112 may prevent gases produced on each side of the barrier from mixing.

[0021] According to certain reference examples, the barrier 112 may be a solid polymer electrolyte membrane (PEM), such as is available under tradename Nafion from E. I. du Pont de Nemours and Company. For optimum energy conversion in the reactor according to certain reference examples, it is believed that the permeability of the barrier to hydronium ions should preferably be a minimum of two orders of magnitude greater on a molar basis than permeability of the barrier to oxygen under conditions of operation of the reactor. Other suitable PEM membranes that meet these criteria, such as sulfonated polyarylene block copolymers (see, e.g., Bae, B., K Miyatake, and M. Watanabe. *Macromolecules* 43:2684-2691 (2010)) and PTFE-supported Nafion (see, e.g., G.-B. Jung, et al, *J Fuel Cell Technol* 4:248-255(2007)), are under active development in numerous laboratories. Suitable commercial PEM membranes, in addition to Nafion, include Gore-Select (PRIMEA), Flemion (Asahi), 3M Fluoropolymer ionomer, SPEEK (Polyfuel), Kynar blended membrane (Arkema), Fumapem (FuMA-Tech), and Solupor (Lydall).

[0022] In the biological reactor 102, water acts as a primary net electron donor for the methanogenic microorganisms (e.g, methanogenic archaea) in the biological reactor. Accordingly, it is also believed that the barrier 112 should be permeable for hydronium ions (H_3O^+) (i.e., enable hydronium ions to cross the barrier 112 from the anode 110 to the cathode 108 and complete the electrical circuit).

[0023] The cathode 108 may be of a high surface to volume electrically conductive material. For example, the cathode 108 may be made of a porous electrically conductive material. In particular, the cathode 108 may be made from a reticulated vitreous carbon foam according to certain reference examples. As explained in greater detail below, other materials may be used. According to certain reference examples, the pores of the cathode may be large enough (e.g., greater than 1-2 micrometers in minimum dimension) to accommodate living methanogenic microorganisms within the pores. The electrical conductivity of the cathode matrix is preferably at least two orders of magnitude greater than the ion conductivity of the aqueous electrolytic medium contained within its pores.

[0024] It will be recognized that the role of the cathode 108 is to supply electrons to the microorganisms while minimizing side-reactions and minimizing energy loss. Additionally, it is advantageous for the cathode to be inexpensive. At the present time, it is believed that certain materials may be more or less suitable for inclusion in the reactor.

[0025] For instance, platinum cathodes may be less suitable for inclusion in the reactor. In this regard, the platinum provides a surface highly active for catalyzing hydrogen gas production from the combination of protons or hydronium ions with electrons provided by the cathode. The activity of platinum cathode catalysts for hydrogen formation in aqueous solutions is so high that the hydrogen concentration in the vicinity of the catalyst quickly rises above its solubility limit and hydrogen gas bubbles emerge. Despite the fact that the methanogenic microorganisms are evolved to consume hydrogen in the process of methane formation, hydrogen in bubbles re-dissolves only slowly in the medium and is largely unavailable to the microorganisms. Consequently, much of the energy consumed in hydrogen formation at a platinum catalyst does not contribute to methane formation. Additionally, the binding energy of hydrogen is higher than the binding energy per bond of methane. This difference results in an energetic loss when hydrogen gas is produced as an intermediate step.

[0026] On the other hand, a solid carbon cathode is an example of an inexpensive, electrically conductive material that has low activity for hydrogen formation and that can provide electrons to microorganisms. However, it will be recognized that electron transfer between microorganisms and an external electron source or sink, such as an electrode, requires some level of proximity between the microorganisms and the electrode and the total rate of electron transfer is related to the area of electrode in close contact with microorganisms. Since a porous electrode that allows the microorganisms to enter the pores has a much larger surface area in proximity to the microorganisms than a planar electrode of equivalent dimensions, the porous electrode is expected to provide superior volumetric current density.

[0027] A suitable porous cathode material may be provided by reticulated vitreous carbon foam, as demonstrated in

Example 1. It is inexpensive and conductive. Its porous structure provides for electrical connections to a large number of the microorganisms allowing for a high volumetric productivity. Additionally, the vitreous nature of the carbon provides low activity for hydrogen production, which increases both energetic and Faradaic efficiency. It will also be recognized that vitreous carbon is also very resistant to corrosion.

[0028] Other suitable porous electrode materials may include, but are not limited to graphite foam (see, e.g., US Patent 6033506), woven carbon and graphite materials, carbon, graphite or carbon nanotube impregnated paper (see, e.g., Hu, L., et al. Proc Nat Acad Sci USA 106: 21490-4 (2009)), and metal foams, or woven or non-woven mesh comprised of materials, such as titanium, that are non-reactive under the conditions of the reaction and that present a high surface to volume ratio.

[0029] Further enhancement of electron transfer between the cathode and the microorganisms may be achieved with conductive fibers. Suitable conductive fibers may consist of conductive pili generated by the microorganisms as described in more detail below. Alternatively or additionally, nanowires, such as carbon nanotubes (Iijima, S. Nature 354:56 (1991)), may be attached directly to the cathode. Wang, J. et al, J. Am. Chem. Soc. 125:2408-2409 (2003) and references therein, provide techniques for modifying glassy carbon electrodes with carbon nanotubes. Additionally, conductive organic polymers may be used for this purpose (see, e.g., Jiang, P. Angewandte Chemie 43:4471-4475 (2004)). Non-conductive materials that bind the microorganisms to the surface of the electrode may also enhance electron transfer. Suitable non-conductive binders include but are not limited to poly-cationic polymers such as poly-lysine or poly(beta-aminosulfonamides). The living methanogenic microorganisms may also produce biological materials, such as those that support biofilm formation, that effectively bind them to the surface of the electrode.

[0030] The anode 110 may comprise a Pt-carbon catalytic layer or other materials known to provide low overpotential for the oxidation of water to oxygen.

[0031] As illustrated in Fig. 3, a source of electricity 120 is coupled to the anode 110 and the cathode 108. As mentioned above, the source 120 may be generated from carbon-free, renewable sources. In particular, the source 120 may be generated from carbon-free, renewable sources such as solar sources (e.g., photovoltaic cell arrays) and wind sources (e.g., wind turbines). However, according to other reference examples, the source 120 may be a coal power plant, a fuel cell, a nuclear power plant. According to still further reference examples, the source 120 may be a connector to an electrical transmission grid. Further details are provided below.

[0032] Based upon dynamic computational models of porous electrodes containing aqueous electrolyte, the optimal conductivity of the cathode electrolyte is believed to be preferably in the range of 0.01 to 0.25 S/cm or higher in the operating state of the reactor. Higher conductivity of the electrolyte may reduce ohmic losses in the reactor and hence may increase energy conversion efficiency. Computational models further suggest that the optimal thickness of the porous cathode (perpendicular to the planes of the reactor layers) may be between 0.2 cm and 0.01 cm, or less. Thinner cathode layers may have lower ohmic resistance under a given set of operating conditions and hence may have an increased energy conversion efficiency.

[0033] The biological reactor 102 may operate at an electrical current density above 6 mA/cm². For example, the biological reactor 102 may operate at an electrical current density of between 6 and 10 mA/cm². According to certain reference examples, the biological reactor 102 may operate at electrical current densities at least one order of magnitude higher (e.g., 60-100 mA/cm²). The current may be supplied as direct current, or may be supplied as pulsed current such as from rectified alternating current. The frequency of such pulsed current is not constrained by the properties of the reactor. The frequency of the pulsed current may be variable, such as that generated by variable speed turbines, for example wind turbines lacking constant-speed gearing.

[0034] The living methanogenic microorganisms (e.g., autotrophic and/or hydrogenotrophic methanogenic archaea) may be impregnated into the cathode 108. While various reference examples and variants of the microorganisms are described in greater detail in the following section, it is noted that the microorganisms may be a strain of archaea adapted to nearly stationary growth conditions according to certain reference examples. In addition, according to certain reference examples, the microorganisms may be Archaea of the subkingdom *Euryarchaeota*, in particular, the microorganisms may consist essentially of *Methanothermobacter thermautotrophicus*.

[0035] As explained in greater detail below, the biological reactor 102 may have an operating state wherein the culture is maintained at a temperature above 50° C, although certain reference examples may have an operating state in the range of between approximately 60° C and 100° C. The biological reactor 102 may also have a dormant state wherein electricity and/or carbon dioxide is not supplied to the reactor 102. According to such a dormant state, the production of methane may be significantly reduced relative to the operating state, such that the production may be several orders of magnitude less than the operating state, and likewise the requirement for input electrical power and for input carbon dioxide may be several orders of magnitude less than the operating state. According to certain reference examples, the biological reactor 102 may change between the operating state and the dormant state or between dormant state and operating state without addition of microorganisms to the reactor 102. Additionally, according to certain reference examples, the reactor 102 may change between dormant and operating state rapidly, and the temperature of the reactor 102 may be maintained during the dormant state to facilitate the rapid change.

[0036] The biological reactor 102 may have an inlet 130 connected to the first chamber for receiving gaseous carbon dioxide. The inlet 130 may be coupled to a supply of carbon dioxide 132 to couple the supply of carbon dioxide to the first chamber 104. The biological reactor 102 may also have an outlet 134 to receive methane from the first chamber.

[0037] The biological reactor 102 may also have an outlet 136 connected to the second chamber 106 for receiving byproducts. For example, gaseous oxygen may be generated in the second chamber 106 as a byproduct of the production of methane in the first chamber 104. According to certain reference examples, oxygen may be the only gaseous byproduct of the biological reactor 102. In either event, the gaseous oxygen may be received by the outlet 134 connected to the second chamber 106.

[0038] In keeping with the reference example of Fig. 3, a method of the present disclosure may include supplying electricity to the anode 110 and the cathode 108 of the biological reactor 102 having at least the first chamber 104 containing at least the cathode 108, a culture comprising living methanogenic microorganisms (e.g., autotrophic and/or hydrogenotrophic methanogenic archaea), and water (e.g., as part of an aqueous electrolytic medium compatible with the living microorganisms), and the second chamber 106 containing at least the anode 110, wherein the culture is maintained at a temperature above 50 °C. Further, the method may include generating electricity from carbon-free, renewable sources, such as from solar and wind sources, as noted above. According to certain reference examples, electricity may be supplied during a non-peak demand period. Further details are provided in section III, below.

[0039] The method may also include supplying carbon dioxide to the first chamber 104. As noted above, the method may include recycling carbon dioxide from at least a concentrated industrial source or atmospheric carbon dioxide, which carbon dioxide is supplied to the first chamber 104.

[0040] The method may further include collecting methane from the first chamber 104. The method may further include storing and transporting the methane. The method may also include collecting other gaseous products or byproducts of the biological reactor; for example, the method may include collecting oxygen from the second chamber 106.

[0041] It will be recognized that while the system of Fig. 3 may be viewed as operating to convert electricity into methane, it is also possible to view the system of Fig. 3 as operating to create or earn carbon credits, as an alternative to carbon sequestration for example. According to such a method, the method would include supplying electricity to the anode 110 and the cathode 108 of biological reactor 102 having at least the first chamber 104 containing at least the cathode 108, methanogenic microorganisms (e.g., methanogenic archaea), and water (e.g., as part of an aqueous electrolytic medium compatible with the living microorganisms), and a second chamber containing at least the anode, wherein the culture is maintained at a temperature above 50 °C. The method would also include supplying carbon dioxide to the first chamber 104. Finally, the method would include receiving carbon credits for the carbon dioxide converted in the biological reactor 102 into methane. According to such a method, the carbon dioxide may be recycled from a concentrated industrial source.

[0042] It will be recognized that the system 100 is only one such reference example of a system. Additional embodiments and variants of the system 100 are illustrated in Figs. 4-10, and will be described in the following section. While these embodiments are generally shown in cross-section, assuming a generally cylindrical shape for the reactor and disc-like shapes for the anode and cathode, which may be arranged parallel to one another as illustrated, it will be appreciated that other geometries may be used instead.

[0043] Fig. 4 illustrates a system 200 that includes a biological reactor 202, a source of electricity 204 and a source of carbon dioxide 206. As illustrated, the source of electricity 204 and the source of carbon dioxide 206 are both coupled to the biological reactor 202. The biological reactor 202 uses a circulating liquid/gas media, as explained in greater detail below.

[0044] The biological reactor 202 includes a housing 210 that defines, in part, first and second chambers 212, 214. The reactor 202 also includes a cathode 216 disposed in the first chamber 212, and an anode 218 disposed in the second chamber 214. The first and second chambers 212, 214 are separated by proton permeable, gas impermeable barrier 220, the barrier 220 having surfaces 222, 224 which also define in part the first and second chambers 212, 214.

[0045] The biological reactor 202 also includes current collectors 230, 232, one each for the cathode 216 and the anode 218. The current collector 230 for the cathode 216 may be made as a solid disc of material, so as to maintain a sealed condition within the chamber 212 between an inlet 234 for the carbon dioxide and an outlet 236 for the methane (and potentially byproducts). The inlet 234 and the outlet 236 may be defined in the housing 210. The current collector 232 for the anode 218 may also define a porous gas diffusion layer, on which the anode catalyst layer is disposed. It will be recognized that a porous gas diffusion layer should be provided so as to permit gaseous byproducts to exit the second chamber 214, because the barrier 220 prevents their exit through the outlet 236 via the first chamber 212.

[0046] In keeping with the disclosure above, the cathode 216 is made of a porous material, such as a reticulated carbon foam. The cathode 216 is impregnated with the methanogenic microorganisms and with the aqueous electrolytic medium. The methanogenic microorganisms (e.g., archaea) are thus in a passage 238 formed between the barrier 220 and the current collector 230 between the inlet 234 and the outlet 236.

[0047] In operation, carbon dioxide is dissolved into the aqueous electrolytic medium and is circulated through the cathode 216. The methanogenic microorganisms may reside within the circulating electrolytic medium or may be bound

to the porous cathode 216. In the presence of an electric current, the methanogenic microorganisms process the carbon dioxide to generate methane. The methane is carried by the electrolytic medium out of the reactor 202 via the outlet 236. According to such an embodiment, post-processing equipment, such as a liquid/gas separator, may be connected to the outlet to extract the methane from the solution.

[0048] Fig. 5 illustrates a system 250 including a reactor 252 that is a variant of that illustrated in Fig. 4. Similar to the reactor 202, the reactor 252 includes a housing 260 that defines, in part, first and second chambers 262, 264. The reactor 252 also includes a cathode 266 disposed in the first chamber 262, and an anode 268 disposed in the second chamber 264. The first and second chambers 262, 264 are separated by proton permeable, gas impermeable barrier 270, the barrier 270 having surfaces 272, 274 that also define in part the first and second chambers 262, 264.

[0049] Unlike the embodiment illustrated in Fig. 4, the embodiment illustrated in Fig. 5 also includes a porous, proton conducting gas diffusion layer 280. The gas diffusion layer 280 is disposed between the cathode 266 and the barrier 270. Using this gas diffusion layer 280, gaseous carbon dioxide may enter the first chamber 212 through the gas diffusion layer 280 and then diffuse into the cathode 266, while gaseous methane produced by the microorganisms may diffuse from the cathode 266 into the layer 280 and then out of the first chamber 212. Proton-conducting gas diffusion layers suitable for use as layer 280 may be produced by coating porous materials with proton-conducting ionomer, by incorporating ionomer directly into the porous matrix, or by chemical derivitization of porous matrix materials with sulfate, phosphate, or other groups that promote proton-conduction, for example.

[0050] It will thus be recognized that the carbon dioxide and the methane are not carried by a circulating liquid media according to the embodiment of Fig. 5. Instead, the culture and the media are contained in the first chamber 262, while only the gaseous carbon dioxide and the methane circulate between inlet and outlet. Such an embodiment may present certain advantages relative to the reactor 202 of Fig. 4, in that the handling of the methane post-processing or generation may be simplified. Further, the absence of a circulating liquid media in the reactor 202 may simplify the serial connection between multiple reactors, as illustrated in Fig. 11. However, while the circulating media in the embodiment of Fig. 4 provided any water required by the culture, it may be necessary to couple equipment to the reactor to provide water vapor to the culture, in addition to the gaseous carbon dioxide. The electrolytic medium and microorganisms may be retained within the pores of the cathode 266 by surface tension or alternatively by including materials within the electrolyte that increase its viscosity or form a gel.

[0051] Fig. 6 illustrates a system 300 including a reactor 302 that is a variant of that illustrated in Fig. 5. Similar to the reactors 202 and 252, the reactor 302 includes a housing 310 that defines, in part, first and second chambers 312, 314. The reactor 302 also includes a cathode 316 disposed in the first chamber 312, and an anode 318 disposed in the second chamber 314. The first and second chambers 312, 314 are separated by proton permeable, gas impermeable barrier 320, the barrier 320 having surfaces 322, 324 that also define in part the first and second chambers 312, 314.

[0052] Moreover, similar to the embodiment illustrated in Fig. 5, the embodiment illustrated in Fig. 6 also includes a porous, proton conducting gas diffusion layer 330. However, the gas diffusion layer 330 is not disposed between the cathode 316 and the barrier 320, but instead is disposed between the cathode 316 and the current collector 332. In this arrangement, the gas diffusion layer 330 is current-conducting rather than proton-conduction like the gas diffusion layer 280 in reactor 252. Current would pass through the layer 330 into the cathode 316. As in the reactor 252, the carbon dioxide still would enter the first chamber 312 passes through the gas diffusion layer 330 and diffuse into the cathode 316, while methane produced by the microorganisms would diffuse from the cathode 316 through the layer 330.

[0053] As a result, the embodiment of Fig. 6 illustrates a reactor wherein the gaseous carbon dioxide enters the cathode from a side or along a path opposite that of the protons. By comparison, the embodiment of Fig. 5 illustrates a reactor wherein the gaseous carbon dioxide and the protons enter the cathode from the same side or along a similar path. The counter-diffusion of the embodiment of Fig. 6 may provide slower production than that of Fig. 5, but may provide acceptable production levels. As to the material used for the barrier 320 according to such an embodiment, it is believed that a porous carbon foam impregnated with Nafion particles may be suitable.

[0054] Figs. 7-10 illustrate a system 400 including a biological reactor 402 that highlights several aspects of the present disclosure over and above those illustrated in Figs. 2-6. In particular, while the general nature of the reactor (with first and second chambers, anode, cathode, barrier, microorganisms, and aqueous electrolytic medium) has much in common with the systems illustrated in Figs. 2-6, the reactor 402 illustrates new geometries, as well as a reactor in which a plurality of anodes and a plurality of cathodes are present.

[0055] In particular, as illustrated in Fig. 7, the reactor 402 includes a number of tubular reactor subunits 404 that may be arranged in a matrix format. It will be recognized that the particular arrangement of the subunits 404 utilizes an offset relative to the arrangement of adjacent rows of subunits 404, so as to increase the number of subunits 404 within a volume. It will also be recognized that adjacent rows of subunits 404 may be aligned with each other instead. It will also be recognized that while four rows of five subunits 404 each and four rows of four subunits 404 each have been illustrated, this should not be taken as limiting the reactor 402 thereby.

[0056] Fig. 8 illustrates a plurality of subunits in cross-section, so as to appreciate the similarities and differences with the systems illustrated in Figs. 2-6 above. While it need not be the case for all embodiments, each of the subunits 404

illustrated in Fig. 8 is identical, such that discussion of any one of the subunits 404 would be inclusive of remarks that may be made relative to the other subunits 404 as well.

[0057] As seen in Fig. 8, the reactor 402 includes a housing 410, in which the subunits 404 are disposed. It will be recognized that the housing 410 is sealed against leakage of products and byproducts as explained in greater detail below. Disposed at one end of the housing 410 is a common current collector 412 that is connected to a generally tubular cathode 414 of each of the subunits 404. In a similar fashion, the reactor 402 includes a porous gas diffusion layer/current collector 416 that is connected to a generally tubular anode 418 of each subunit 404. Disposed between the cathode 414 and the anode 418 is a generally tubular proton-permeable, gas impermeable barrier 420, as is discussed in greater detail above. This arrangement is also illustrated in Fig. 9.

[0058] According to this embodiment, the carbon dioxide enters the reactor 402 via an inlet 430 and moves along a passage 432. The carbon dioxide then passes along the porous cathode 414, which is impregnated with methanogenic microorganisms and aqueous electrolytic medium. The methane produced in the cathode 414 then is collected in a space 434 that is connected to the outlet 436.

[0059] Fig. 10 illustrates a variant to the subunit 404 illustrated relative to the system 400 in Figs. 7 and 8. Given the similarities between the subunit 404 and its variant, the common structures will be designated with a prime.

[0060] As illustrated in Fig. 10, the subunit 404' includes a tubular cathode 414', a tubular anode 418' and a tubular barrier 420'. As in the subunit 404, the tubular cathode 414' is disposed centrally of the subunit 404', with the anode 418' disposed radially outward of the cathode 416' and the barrier 420' disposed therebetween. However, similar to the variants described in Fig. 5, the subunit 404' includes a porous, proton-conducting gas diffusion layer 440. This layer 440 may be in communication with the passage 432 and the space 434 in a reactor 402, instead of the cathode 414'. As such, carbon dioxide would pass from the inlet 430 through the layer 440 to the cathode 414', while methane would pass from the cathode 414' through the layer 440 to the outlet 436. An arrangement similar to Fig. 10, but with an electrically conductive gas diffusion layer arranged as in Fig 6 between the cathode 414' and the current collector 412' is also possible.

[0061] Figs. 11 and 12 illustrate two different power management options that may be used with any of the reactors described above. In this regard, it will be recognized that each of the systems 450, 452 illustrated in Figs. 11 and 12 may include a plurality of individual reactors 454, 456.

[0062] In Fig. 11, the individual reactors 454 are connected in series to match a fixed or constant voltage. The system 450 accommodates a variable current by providing a plurality of switches 458 to permit additional series chains of reactors 454 to be switched into the circuit to match variable current. In Fig. 12, the individual reactors 456 are connected in parallel to match a fixed or constant current. The system 452 accommodates a variable voltage by providing pairs of switches 460 to permit additional parallel planes of reactors 456 to be switched into the circuit to match variable voltage. It will be recognized that it may also be possible to address variable current and variable voltage applications with addressable switching so as to build dynamic parallel reactor planes and to adjust the lengths of series chains as needed.

II. Cultures comprising methanogenic microorganisms

Cultures

[0063] With regard to the present invention, the reactor (also referred to herein as the electromethanogenic reactor, the electrobiochemical methanogenesis reactor, the biological reactor, the bioreactor, etc.) comprises a culture comprising methanogenic microorganisms (a term used interchangeably with "methanogens"). The term "culture" as used herein refers to a population of live microorganisms in or on culture medium. When part of the reactor, the culture medium also serves as the electrolytic medium facilitating electrical conduction within the reactor.

Monocultures, Substantially Pure Cultures

[0064] In some embodiments, the culture is a monoculture and/or is a substantially-pure culture. As used herein the term "monoculture" refers to a population of microorganisms derived or descended from a single species (which may encompass multiple strains) or a single strain of microorganism. The monoculture in some aspects is "pure," i.e., nearly homogeneous, except for (a) naturally-occurring mutations that may occur in progeny and (b) natural contamination by non-methanogenic microorganisms resulting from exposure to non-sterile conditions. Organisms in monocultures can be grown, selected, adapted, manipulated, modified, mutated, or transformed, e.g. by selection or adaptation under specific conditions, irradiation, or recombinant DNA techniques, without losing their monoculture nature.

[0065] As used herein, a "substantially-pure culture" refers to a culture that substantially lacks microorganisms other than the desired species or strain(s) of microorganism. In other words, a substantially-pure culture of a strain of microorganism is substantially free of other contaminants, which can include microbial contaminants (e.g., organisms of different species or strain). In some embodiments, the substantially-pure culture is a culture in which greater than or

about 70%, greater than or about 75%, greater than or about 80%, greater than or about 85%, greater than or about 90%, greater than or about 91%, greater than or about 92%, greater than or about 93%, greater than or about 94%, greater than or about 95%, greater than or about 96%, greater than or about 97%, greater than or about 98%, greater than or about 99% of the total population of the microorganisms of the culture is a single, species or strain of methanogenic microorganism. By way of example, in some embodiments, the substantially-pure culture is a culture in which greater than 70%, 75%, 80%, 85%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99% or more of the total population of microorganisms of the culture is a single methanogenic microorganism species, e.g., *Methanothermobacter thermautotrophicus*.

[0066] When initially set up, the biological reactor is inoculated with a pure or substantially pure monoculture. As the biological reactor is exposed to non-sterile conditions during operation, the biological reactor may be contaminated by other non-methanogenic microorganisms in the environment without significant impact on operating efficiency over a period of 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 months, or 1.5 or 2 years.

Mixed Cultures

[0067] In other embodiments, the culture comprises a plurality of (e.g., a mixture or combination of two or more) different species of methanogenic microorganisms. In some aspects, the culture comprises two, three, four, five, six, seven, eight, nine, ten, or more different species of methanogenic microorganisms. In some aspects, the culture comprises a plurality of different species of methanogenic microorganisms, but the culture is substantially free of any non-methanogenic microorganism.

[0068] In yet other embodiments, the culture comprises a plurality of microorganisms of different species, in which at least one is a methanogenic microorganism. In some aspects of this embodiment, the culture comprises at least one species of methanogenic microorganism and further comprises at least one selected non-methanogenic microorganism. In some aspects, the culture comprises two or more different species of methanogens, and, optionally comprises at least one selected non-methanogenic microorganism.

[0069] Suitable cultures of mixtures of two or more microbes are also readily isolated from the specified environmental sources (Bryant et al. Archiv Microbiol 59:20-31 (1967) "Methanobacillus omelianskii, a symbiotic association of two species of bacteria). Suitable mixtures may be consortia in which cells of two or more species are physically associated or they may be syntrophic mixtures in which two or more species cooperate metabolically without physical association. Also, suitable mixtures may be consortia in which cells of two or more species are physically associated or they may be syntrophic mixtures in which two or more species cooperate metabolically with physical association. Mixed cultures may have useful properties beyond those available from pure cultures of known hydrogenotrophic methanogens. These properties may include, for instance, resistance to contaminants in the gas feed stream, such as oxygen, ethanol, or other trace components, or aggregated growth, which may increase the culture density and volumetric gas processing capacity of the culture. Another contaminant in the gas feed stream may be carbon monoxide.

[0070] Suitable cultures of mixed organisms may also be obtained by combining cultures isolated from two or more sources. One or more of the species in a suitable mixed culture should be an Archaeal methanogen. Any non-Archaeal species may be bacterial or eukaryotic.

[0071] Mixed cultures have been described in the art. See, for example, Cheng et al., U.S. 2009/0317882, and Zeikus US 2007/7250288.

Reactor States and Growth Phases

[0072] As described herein, the reactor may be in a dormant (e.g., off) state or in an operating (e.g., on) state with regard to the production of methane, and, consequently, the reactor may be turned "on" or "off as desired in accordance with the need or desire for methane production. In some embodiments, the methanogenic microorganisms of the culture are in a state which accords with the state of the reactor. Therefore, in some embodiments, the methanogenic microorganisms are in a dormant state in which the methanogenic microorganisms are not producing methane (e.g., not producing methane at a detectable level). In alternative embodiments, the methanogenic microorganisms are in an operating state in which the methanogenic microorganisms are producing methane (e.g., producing methane at a detectable level).

[0073] When the methanogenic microorganisms are in the operating state, the methanogenic microorganisms may be in one of a variety of growth phases, which differ with regard to the growth rate of the microorganisms (which can be expressed, e.g., as doubling time of microorganism number or cell mass). The phases of growth typically observed include a lag phase, an active growth phase (also known as exponential or logarithmic phase when microorganisms multiply rapidly), a stationary phase, and a death phase (exponential or logarithmic decline in cell numbers). In some aspects, the methanogenic microorganisms of the biological reactor are in a lag phase, an active growth phase, a stationary phase, or a nearly stationary phase.

Active growth phase

[0074] In some embodiments, the methanogenic microorganisms are in an active growth phase in which the methanogenic microorganisms are actively multiplying at a rapid rate.

[0075] In some aspects, during operation of the biological reactor, the doubling time of the microorganisms may be rapid or similar to that observed during the growth phase in its natural environment or in a nutrient-rich environment. For example, the doubling time of many methanogenic microorganisms in the active growth phase is about 15 minutes, about 20 minutes, about 30 minutes, about 45 minutes, about 60 minutes, about 75 minutes, about 80 minutes, about 90 minutes, or about 2 hours.

Stationary growth phase, nearly stationary growth phase

[0076] Stationary phase represents a growth phase in which, after the logarithmic or active growth phase, the rate of cell division and the rate of cell death are in equilibrium or near equilibrium, and thus a relatively constant concentration of microorganisms is maintained in the reactor. (See, Eugene W. Nester, Denise G. Anderson, C. Evans Roberts Jr., Nancy N. Pearsall, Martha T. Nester; Microbiology: A Human Perspective, 2004, Fourth Edition, Chapter 4).

[0077] In other embodiments, the methanogenic microorganisms are in an stationary growth phase or nearly stationary growth phase in which the methanogenic microorganisms are not rapidly growing or have a substantially reduced growth rate. In some aspects, the doubling time of the methanogenic microorganisms is about 1 week or greater, including about 2, 3, 4 weeks or greater, or 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 or 12 months or greater.

[0078] In some embodiments, the reactor comprises a culture comprising methanogenic microorganisms, which microorganisms are initially in an active growth phase, and subsequently in a stationary or nearly stationary phase. In some embodiments, the reactor comprises a culture comprising methanogenic microorganisms which cycle between a dormant and an operating state.

Methanogenesis

[0079] As used herein, the term "methanogenic" refers to microorganisms that produce methane as a metabolic byproduct. In some embodiments, the reactor (also referenced herein interchangeably as electromethanogenic reactor, biological reactor or bioreactor, etc.) comprises a culture comprising hydrogenotrophic methanogenic microorganisms. As used herein, the term "hydrogenotrophic" refers to a microorganism capable of converting hydrogen to another compound as part of its metabolism. Hydrogenotrophic methanogenic microorganisms are capable of utilizing hydrogen in the production of methane. In some embodiments, the reactor comprises a culture comprising autotrophic methanogenic microorganisms. As used herein, the term "autotrophic" refers to a microorganism capable of using carbon dioxide and a source of reducing power to provide all carbon and energy necessary for growth and maintenance of the cell (e.g., microorganism). Suitable sources of reducing power may include but are not limited to hydrogen, hydrogen sulfide, sulfur, formic acid, carbon monoxide, reduced metals, sugars (e.g., glucose, fructose), acetate, photons, or cathodic electrodes or a combination thereof. In some aspects, the methanogenic microorganisms produce methane from carbon dioxide, electricity, and water, a process referred to as electrobiochemical methanogenesis.

[0080] The methanogenic microorganisms produce substantial amounts of methane in the operating state, as described herein. In some aspects, the methanogenic microorganisms produce methane in an active growth phase or stationary growth phase or nearly stationary growth phase.

[0081] The efficiency of methane production per molecule of carbon dioxide (CO₂) by the methanogenic microorganisms may be any efficiency suitable for the purposes herein. It has been reported that naturally-occurring methanogenic microorganisms in the active growth phase produce methane at a ratio of about 8 CO₂ molecules converted to methane per molecule of CO₂ converted to cellular material, ranging up to a ratio of about 20 CO₂ molecules converted to methane per molecule of CO₂ converted to cellular material. In some embodiments, the methanogenic microorganisms of the biological reactor of the present invention demonstrate an increased efficiency, particularly when adapted to stationary phase growth conditions. Accordingly, in some aspects, the ratio of the number of CO₂ molecules converted to methane to the number of CO₂ molecules converted to cellular material is higher than the ratio of naturally-occurring methanogenic microorganisms in the active growth phase. In exemplary embodiments, the ratio of the number of CO₂ molecules converted to methane to the number of CO₂ molecules converted to cellular material is N:1, wherein N is a number greater than 20, e.g. about 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, or higher. In some aspects, N is less than 500, less than 400, less than 300, or less than 200. In some aspects, N ranges from about 40 to about 150.

ArchaeaNaturally-Occurring Archaea

[0082] In some embodiments, the methanogenic microorganisms, e.g., the autotrophic methanogenic microorganisms, are archaea. The term "Archaea" refers to a categorization of organisms of the division *Mendosicutes*, typically found in unusual environments and distinguished from the rest of the prokaryotes by several criteria, including ether-linked membrane lipids and lack of muramic acid in cell walls. On the basis of ssrRNA analysis, the Archaea consist of two phylogenetically-distinct groups: *Crenarchaeota* and *Euryarchaeota*. On the basis of their physiology, the Archaea can be organized into three partially overlapping groupings: methanogens (prokaryotes that produce methane); extreme halophiles (prokaryotes that live at very high concentrations of salt (NaCl); and extreme (hyper) thermophiles (prokaryotes that live at very high temperatures - e.g., 50-122°C). Besides the unifying archaeal features that distinguish them from bacteria (i.e., no murein in cell wall, ether-linked membrane lipids, etc.), these prokaryotes exhibit unique structural or biochemical attributes which adapt them to their particular habitats. The *Crenarchaeota* consist mainly of hyperthermophilic sulfur-dependent prokaryotes and the *Euryarchaeota* contain the methanogens and extreme halophiles.

[0083] Methanogens (or methanobacteria) suitable for practice of the invention are readily obtainable from public collections of organisms or can be isolated from a variety of environmental sources. Such environmental sources include anaerobic soils and sands, bogs, swamps, marshes, estuaries, dense algal mats, both terrestrial and marine mud and sediments, deep ocean and deep well sites, sewage and organic waste sites and treatment facilities, and animal intestinal tracts and feces. Examples of suitable organisms have been classified into four different genera within the Methanobacteria class (e.g. *Methanobacterium alcaliphilum*, *Methanobacterium bryantii*, *Methanobacterium congolense*, *Methanobacterium defluvii*, *Methanobacterium espanolae*, *Methanobacterium formicicum*, *Methanobacterium ivanovii*, *Methanobacterium palustre*, *Methanobacterium thermaggregans*, *Methanobacterium uliginosum*, *Methanobrevibacter acididurans*, *Methanobrevibacter arboriphilicus*, *Methanobrevibacter gottschalkii*, *Methanobrevibacter olleyae*, *Methanobrevibacter rum inantium*, *Methanobrevibacter smithii*, *Methanobrevibacter woesei*, *Methanobrevibacter wolunii*, *Methanothermobacter marburgensis*, *Methanothermobacter thermoautotrophicum* (also known as *Methanothermobacter thermoautotrophicus*), *Methanothermobacter thermoflexus*, *Methanothermobacter thermophilus*, *Methanothermobacter wolfeii*, *Methanothermus sociabilis*), 5 different genera within the Methanomicrobia class (e.g. *Methanocorpusculum bavaricum*, *Methanocorpusculum parvum*, *Methanoculleus chikuoensis*, *Methanoculleus submarinus*, *Methanogenium frigidum*, *Methanogenium liminatans*, *Methanogenium marinum*, *Methanosarcina acetivorans*, *Methanosarcina barkeri*, *Methanosarcina mazei*, *Methanosarcina thermophila*, *Methanomicrobium mobile*), 7 different genera within the Methanococci class (e.g. *Methanocaldococcus jannaschii*, *Methanococcus aeolicus*, *Methanococcus maripaludis*, *Methanococcus vanniellii*, *Methanococcus voltaei*, *Methanothermococcus thermolithotrophicus*, *Methanocaldococcus fervens*, *Methanocaldococcus indicus*, *Methanocaldococcus infernus*, *Methanocaldococcus vulcanius*), and one genus within the Methanopyri class (e.g. *Methanopyrus kandleri*). Suitable cultures are available from public culture collections (e.g. the American Type Culture Collection, the Deutsche Sammlung von Mikroorganismen und Zellkulturen GmbH, and the Oregon Collection of Methanogens). In some embodiments, the methanogen is selected from the group consisting of *Methanosarcinia barkeri*, *Methanococcus maripaludis*, and *Methanothermobacter thermoautotrophicus*.

[0084] Additional species of methanogens suitable for purposes of the present invention include, but are not limited to, *Methanobacterium formicum*, *Methanobrevibacter ruminantium*, *Methanocalculus chunghsingensis*, *Methanococcoides burtonii*, *Methanococcus deltae*, *Methanocorpusculum labreanum*, *Methanoculleus bourgensis* (*Methanogenium olentangyi*, *Methanogenium bourgense*), *Methanoculleus marisnigri*, *Methanogenium cariaci*, *Methanogenium organophilum*, *Methanopyrus kandleri*, *Methanoregula boonei*. In some embodiments, the biological reactor comprises a culture (e.g. monoculture or substantially pure culture) of thermophilic or hyperthermophilic microorganisms, which may also be halophiles. In some embodiments, the methanogenic microorganism is from the phylum *Euryarchaeota*. Examples of species of thermophilic or hyperthermophilic autotrophic methanogens suitable for the purposes of the present invention include *Methanocaldococcus fervens*, *Methanocaldococcus indicus*, *Methanocaldococcus infernos*, *Methanocaldococcus jannaschii*, *Methanocaldococcus vulcanius*, *Methanopyrus kandleri*, *Methanothermobacter defluvii*, *Methanothermobacter marburgensis*, *Methanothermobacter thermoautotrophicus*, *Methanothermobacter thermoflexus*, *Methanothermobacter thermophilus*, *Methanothermobacter wolfeii*, *Methanothermococcus okinawensis*, *Methanothermococcus thermolithotrophicus*, *Methanothermus fervidus*, *Methanothermus sociabilis*, *Methanotorris formicicus*, and *Methanotorris igneus*.

[0085] In accordance with the foregoing, in some embodiments, the methanogenic microorganisms are of the superkingdom Archaea, formerly called Archaeobacteria. In certain aspects, the archaea are of the phylum: *Crenarchaeota*, *Euryarchaeota*, *Korarchaeota*, *Nanoarchaeota*, or *Thaumarchaeota*. In some aspects, the *Crenarchaeota* are of the class *Thermoprotei*. In some aspects, the *Euryarchaeota* are of the class: *archaeoglobi*, *halobacteria*, *methanobacteria*, *methanococci*, *methanomicrobia*, *methanopyri*, *thermococci*, *thermoplasmata*. In some embodiments, the *Korarchaeota* are of the class: *Candidatus Korarchaeum* or *korarchaeote* SRI-306. In some aspects, the *Nanoarchaeota* are of the

class nanoarchaeum. In some aspects, the *Thaumarchaeota* is of the class *Cenarchaeales* or marine archaeal group 1.

[0086] In some embodiments, the methanogenic microorganisms are of the order: *Candidatus Korarchaeum*, *Nanoarchaeum*, *Caldisphaerales*, *Desulfurococcales*, *Fervidicoccales*, *Sulfolobales*, *Thermoproteales*, *Archaeoglobales*, *Halobacteriales*, *Methanobacteriales*, *Methanococcales*, *Methanocellales*, *Methanomicrobiales*, *Methanosarcinales*, *Methanopyrales*, *Thermococcales*, *Thermoplasmatales*, *Cenarchaeales*, or *Nitrosopumilales*.

[0087] In some embodiments, the culture comprises a classified species of the Archaea phylum *Euryarchaeota*, including, but not limited to, any of those set forth in Table 1. In some embodiments, the culture comprises an unclassified species of *Euryarchaeota*, including, but not limited to, any of those set forth in Table 2. In some embodiments, the culture comprises an unclassified species of Archaea, including, but not limited to, any of those set forth in Table 3.

[0088] In some embodiments, the culture comprises a classified species of the Archaea phylum *Crenarchaeota*, including but not limited to any of those set forth in Table 4. In some embodiments, the culture comprises an unclassified species of the Archaea phylum *Crenarchaeota*, including, but not limited to, any of those set forth in Table 5.

[0089] The archaea listed in Tables 1-5 are known in the art. See, for example, the entries for "Archaea" in the Taxonomy Browser of the National Center for Biotechnological Information (NCBI) website.

Modified Archaea

[0090] Any of the above naturally-occurring methanogenic microorganisms may be modified. Accordingly, in some embodiments, the culture of the reactor comprises methanogenic microorganisms that have been modified (e.g., adapted in culture, genetically modified) to exhibit or comprise certain characteristics or features, which, optionally, may be specific to a given growth phase (active growth phase, stationary growth phase, nearly stationary growth phase) or reactor state (e.g., dormant state, operating state). For example, in some embodiments, the culture of the reactor comprises a methanogenic microorganism that has been modified to survive and/or grow in a desired culture condition which is different from a prior culture condition in which the methanogenic microorganism survived and/or grew, e.g., the natural environment from which the microorganism was isolated, or a culture condition previously reported in literature. The desired culture conditions may differ from the prior environment in temperature, pH, pressure, cell density, volume, humidity, salt content, conductivity, carbon content, nitrogen content, vitamin-content, amino acid content, mineral-content, or a combination thereof. In some embodiments, the culture of the biological reactor comprises a methanogenic microorganism, which, before adaptation in culture or genetic modification, is one that is not a halophile and/or not a thermophile or hyperthermophile, but, through adaptation in culture or genetic modification, has become a halophile and/or thermophile or hyperthermophile. Also, for example, in some embodiments, the methanogenic microorganism before genetic modification is one which does not express a protein, but through genetic modification has become a methanogenic microorganism which expresses the protein. Further, for example, in some embodiments, the methanogenic microorganism before adaptation in culture or genetic modification, is one which survives and/or grows in the presence of a particular carbon source, nitrogen source, amino acid, mineral, salt, vitamin, or combination thereof but through adaptation in culture or genetic modification, has become a methanogenic microorganism which survives and/or grows in the substantial absence thereof. Alternatively or additionally, in some embodiments, the methanogenic microorganism before adaptation in culture or genetic modification, is one which survives and/or grows in the presence of a particular amount or concentration of carbon source, nitrogen source, amino acid, mineral, salt, vitamin, but through adaptation in culture or genetic modification, has become a methanogenic microorganism which survives and/or grows in a different amount or concentration thereof.

[0091] In some embodiments, the methanogenic microorganisms are adapted to a particular growth phase or reactor state. Furthermore, for example, the methanogenic microorganism in some embodiments is one which, before adaptation in culture or genetic modification, is one which survives and/or grows in a given pH range, but through adaptation in culture becomes a methanogenic microorganism that survives and/or grows in different pH range. In some embodiments, the methanogenic microorganisms (e.g., archaea) are adapted in culture to a nearly stationary growth phase in a pH range of about 3.5 to about 10 (e.g., about 5.0 to about 8.0, about 6.0 to about 7.5). Accordingly, in some aspects, the methanogenic microorganisms are adapted in culture to a nearly stationary growth phase at a pH of about 3.5, 3.6, 3.7, 3.8, 3.9, 4.0, 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 5.0, 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9, 6.0, 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8, 6.9, 7.0, 7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 7.7, 7.8, 7.9, 8.0, 8.1, 8.2, 8.3, 8.4, 8.5, 8.6, 8.7, 8.8, 8.9, 9.0, 9.1, 9.2, 9.3, 9.4, 9.5, 9.6, 9.7, 9.8, 9.9, or 10.0. In some embodiments, the methanogenic microorganisms (e.g., archaea) are adapted in culture to an active growth phase in a pH range of about 6.5 to about 7.5 (e.g., about 6.8 to about 7.3). Accordingly, in some aspects, the methanogenic microorganisms are adapted in culture to a nearly stationary growth phase at a pH of about 6.5, 6.6, 6.7, 6.8, 6.9, 7.0, 7.1, 7.2, 7.3, 7.4, or 7.5.

[0092] As used herein, the term "adaptation in culture" refers to a process in which microorganisms (e.g., naturally-occurring archaea) are cultured under a set of desired culture conditions (e.g., high salinity, high temperature, substantial absence of any carbon source, low pH, etc.), which differs from prior culture conditions. The culturing under the desired conditions occurs for a period of time which is sufficient to yield modified microorganisms (progeny of the parental line

(i.e. the unadapted microorganisms)) which survive and/or grow (and/or produce methane) under the desired condition(s). The period of time of adaptation in some aspects is 1 day, 2 days, 3 days, 4 days, 5 days, 6 days, 7 days, 8 days, 9 days, 10 days, 11 days, 12 days, 13 days, 2 weeks, 3 weeks, 4 weeks, 5 weeks, 6 weeks, 1 month, 2 months, 3 months, 4 months, 5 months, 6 months, 7 months, 8 months, 9 months, 10 months, 12 months, 1 year, 2 years. The process of
 5 adapting in culture selects for microorganisms that can survive and/or grow and/or produce methane in the desired culture conditions; these selected microorganisms remain in the culture, whereas the other microorganisms that cannot survive and/or grow and/or produce methane in the desired culture conditions eventually die in the culture. In some
 10 embodiments, as a result of the adaptation in culture, the methanogenic microorganisms produce methane at a higher efficiency, e.g., at a ratio of the number of carbon dioxide molecules converted to methane to the number of carbon dioxide molecules converted to cellular materials which is higher than N:1, wherein N is a number greater than 20, as further described herein.

[0093] In some embodiments, the adaptation process occurs before the microorganisms are placed in the reactor. In some embodiments, the adaptation process occurs after the microorganisms are placed in the reactor. In some embodiments, the microorganisms are adapted to a first set of conditions and then placed in the reactor, and, after placement
 15 into the biological reactor, the microorganisms are adapted to another set of conditions.

[0094] For purposes of the present invention, in some embodiments, the culture of the reactor comprises a methanogenic microorganism (e.g., archaea) which has been adapted in culture to survive and/or grow in a high salt and/or high conductivity culture medium. For example, the culture of the biological reactor comprises a methanogenic microorganism (e.g., archaea) which has been adapted in culture to survive and/or grow in a culture medium having a conductivity of
 20 about 1 to about 25 S/m.

[0095] In alternative or additional embodiments, the culture of the reactor comprises a methanogenic microorganism (e.g., archaea) which has been adapted in culture to survive and/or grow at higher temperature (e.g., a temperature which is between about 1 and about 15 degrees C greater than the temperature that the microorganisms survives and/or grows before adaptation). In exemplary embodiments, the methanogenic microorganisms are adapted to survive and/or
 25 grow in a temperature which is greater than 50 °C, e.g., greater than 55 °C, greater than 60 °C, greater than 65 °C, greater than 70 °C, greater than 75 °C, greater than 80 °C, greater than 85 °C, greater than 90 °C, greater than 95 °C, greater than 100 °C, greater than 105 °C, greater than 110 °C, greater than 115 °C, greater than 120 °C.

[0096] In some embodiments, the culture comprises a methanogenic microorganism (e.g., archaea) which has been adapted in culture to grow and/or survive in conditions which are low in or substantially absent of any vitamins. In some aspects, the culture comprises a methanogenic microorganism (e.g., archaea) which has been adapted in culture to grow and/or survive in conditions which are low in or substantially absent of any organic carbon source. In some embodiments, the culture comprises a methanogenic microorganism which has been adapted in culture to grow and/or survive in conditions with substantially reduced amounts of carbon dioxide. In these embodiments, the methanogenic microorganisms may be adapted to exhibit an increased methanogenesis efficiency, producing the same amount of methane (as compared to the unadapted microorganism) with a reduced amount of carbon dioxide. In some embodiments, the culture comprises a methanogenic microorganism which has been adapted in culture to survive in conditions which substantially lacks carbon dioxide. In these embodiments, the methanogenic microorganisms may be in a dormant phase in which the microorganisms survive but do not produce detectable levels of methane. In some embodiments, the methanogenic microorganisms have been adapted to grow and/or survive in conditions which are low in or substantially absent of any hydrogen. In some embodiments, the methanogenic microorganisms have been adapted to grow and/or survive in conditions which are low in or substantially absent of any external source of water, e.g., the conditions do not comprise a dilution step.

[0097] In exemplary embodiments, the methanogens are adapted in culture to a nearly stationary growth phase. Such methanogens favor methane production over cell growth as measured, e.g., by the ratio of the number of CO₂ molecules converted to methane to the number of CO₂ molecules converted to cellular materials. This ratio is increased as compared to unadapted methanogens (which may exhibit, e.g., a ratio ranging from about 8:1 to about 20:1). In some embodiments, the methanogens are adapted in culture to a nearly stationary growth phase by being deprived of one or more nutrients otherwise required for optimal growth for a prolonged period of time (e.g., 1 week, 2 week, 3 weeks, 1 month, 2 months, 3 months, 4 months, 5 months, 6 months, 7 months, 8 months, 9 months, 10 months, 11 months, 1 year, 2 years, 3 years, 4 years, 5 years or more). In some embodiments, the methanogens are deprived of inorganic nutrients (e.g., hydrogen or electrons) necessary for optimum growth. In some embodiments, depriving the methanogens of hydrogen or electrons is achieved by sparging the media with an inert gas mixture such as Ar:CO₂ at a flow rate of 250 mL/min for several hours until neither hydrogen nor methane appear in the effluent gas stream. In some embodiments, the methanogenic microorganisms have been adapted to a nearly stationary growth phase in conditions which are low in or substantially absent of any external source of water, e.g., the adaptation conditions do not comprise a dilution step.

[0098] In some aspects, the culture comprises a methanogenic microorganism which has been adapted in culture to grow and/or survive in the culture medium set forth herein as Medium 1 and/or Medium 2 or a medium which is substantially similar to Medium 1 or Medium 2.

Genetically modified archaea

[0099] In some embodiments, the culture comprises methanogenic microorganisms which have been purposefully or intentionally genetically modified to become suitable, e.g., more suitable, for the purposes of the present invention. Suitable cultures may also be obtained by genetic modification of non-methanogenic organisms in which genes essential for supporting autotrophic methanogenesis are transferred from a methanogenic microbe or from a combination of microbes that may or may not be methanogenic on their own. Suitable genetic modification may also be obtained by enzymatic or chemical synthesis of the necessary genes.

[0100] In exemplary embodiments, a host cell that is not naturally methanogenic is intentionally genetically modified to express one or more genes that are known to be important for methanogenesis. For example, the host cell in some aspects is intentionally genetically modified to express one or more coenzymes or cofactors involved in methanogenesis. In some specific aspects, the coenzymes or cofactors are selected from the group consisting of F420, coenzyme B, coenzyme M, methanofuran, and methanopterin, the structures of which are known in the art. In some aspects the organisms are modified to express the enzymes, well known in the art, that employ these cofactors in methanogenesis.

[0101] In some embodiments, the host cells that are intentionally modified are extreme halophiles. In other embodiments, the host cells that are intentionally modified are thermophiles or hyperthermophiles. In other embodiments, the host cells that are intentionally modified are non-autotrophic methanogens. In some aspects, the host cells that are intentionally modified are methanogens that are not autotrophic. In some aspects, the host cells that are intentionally modified are cells which are neither methanogenic nor autotrophic. In other embodiments, the host cells that are intentionally modified are host cells comprising synthetic genomes. In some aspects, the host cells that are intentionally modified are host cells which comprise a genome which is not native to the host cell.

[0102] In some embodiments, the culture comprises microorganisms that have been purposefully or intentionally genetically modified to express pili or altered pili, e.g., altered pili that promote cell adhesion to the cathode or other components of the electrobiological methanogenesis reactor or pili altered to become electrically conductive. Pili are thin filamentous protein complexes that form flexible filaments that are made of proteins called pilins. Pili traverse the outer membrane of microbial cells and can extend from the cell surface to attach to a variety of other surfaces. Pili formation facilitates such disparate and important functions as surface adhesion, cell-cell interactions that mediate processes such as aggregation, conjugation, and twitching motility. Recent in silico analyses of more than twenty archaeal genomes have identified a large number of archaeal genes that encode putative proteins resembling type IV pilins (Szabo et al. 2007). The expression of several archaeal pilin-like proteins has since been confirmed in vivo (Wang et al. 2008; Zolghadr et al. 2007; Frols et al. 2007, 2008). The sequence divergence of these proteins as well as the differential expression of the operons encoding these proteins suggests they play a variety of roles in distinct biological processes.

[0103] Certain microorganisms such as *Geobacter* and *Rhodospirillum rubrum* species, have highly conductive pili that can function as biologically produced nanowires as described in US 20060257985. Many methanogenic organisms, including most of the *Methanocaldococcus* species and the *Methanotorris* species, have native pili and in some cases these pili are used for attachment. None of these organisms are known to have natively electrically conductive pili.

[0104] In certain embodiments of the present invention the pili of a methanogenic organism and/or surfaces in contact with pili of a methanogenic organism or other biological components can be altered in order to promote cell adhesion to the cathode or other components of the electrobiological methanogenesis reactor. Pili of a methanogenic organism can be further engineered to optimize their electrical conductivity. Pilin proteins can be engineered to bind to various complexes. For example, pilin proteins can be engineered to bind iron, mimicking the pili of *Geobacter* species or alternatively, they can be engineered to bind a low potential ferredoxin-like iron-sulfur cluster that occurs naturally in many hyperthermophilic methanogens. The desired complex for a particular application will be governed by the midpoint potential of the redox reaction.

[0105] The cells may be genetically modified, e.g., using recombinant DNA technology. For example, cell or strain variants or mutants may be prepared by introducing appropriate nucleotide changes into the organism's DNA. The changes may include, for example, deletions, insertions, or substitutions of, nucleotides within a nucleic acid sequence of interest. The changes may also include introduction of a DNA sequence that is not naturally found in the strain or cell type. One of ordinary skill in the art will readily be able to select an appropriate method depending upon the particular cell type being modified. Methods for introducing such changes are well known in the art and include, for example, oligonucleotide-mediated mutagenesis, transposon mutagenesis, phage transduction, transformation, random mutagenesis (which may be induced by exposure to mutagenic compounds, radiation such as X-rays, UV light, etc.), PCR-mediated mutagenesis, DNA transfection, electroporation, etc.

[0106] The ability of the pili of the methanogenic organisms to adhere to the cathode coupled with an increased ability to conduct electrons, will enable the organisms to receive directly electrons passing through the cathode from the negative electrode of the power source. The use of methanogenic organisms with genetically engineered pili attached to the cathode will greatly increase the efficiency of conversion of electric power to methane.

Culture Media

[0107] The culture comprising the methanogenic microorganisms, e.g., the methanogenic archaea, may be maintained in or on a culture medium. In some embodiments, the culture medium is a solution or suspension (e.g., an aqueous solution). In other embodiments, the culture medium is a solid or semisolid. In yet other embodiments, the culture medium comprises or is a gel, a gelatin, or a paste.

[0108] In some embodiments, the culture medium is one that encourages the active growth phase of the methanogenic microorganisms. In exemplary aspects, the culture medium comprises materials, e.g., nutrients, in non-limiting amounts that support relatively rapid growth of the microorganisms. The materials and amounts of each material of the culture medium that supports the active phase of the methanogenic microorganisms will vary depending on the species or strain of the microorganisms of the culture. However, it is within the skill of the ordinary artisan to determine the contents of culture medium suitable for supporting the active phase of the microorganisms of the culture. In some embodiments, the culture medium encourages or permits a stationary phase of the methanogenic microorganisms. Exemplary culture medium components and concentrations are described in further detail below. Using this guidance, alternative variations can be selected for particular species for electrobiological methanogenesis in the operating state of the biological reactor using well known techniques in the field.

Inorganic materials: Inorganic elements, minerals, and salts

[0109] In some embodiments, the medium for culturing archaea comprises one or more nutrients that are inorganic elements, or salts thereof. Common inorganic elements include but are not limited to sodium, potassium, magnesium, calcium, iron, chloride, sulfur sources such as hydrogen sulfide or elemental sulfur, phosphorus sources such as phosphate and nitrogen sources such as ammonium, nitrogen gas or nitrate. Exemplary sources include NaCl, NaHCO₃, KCl, MgCl₂, MgSO₄, CaCl₂, ferrous sulfate, Na₂HPO₄, NaH₂PO₄ H₂O, H₂S, Na₂S, NH₄OH, N₂, and NaNO₃. In some embodiments, the culture medium further comprises one or more trace elements selected from the group consisting of ions of barium, bromine, boron, cobalt, iodine, manganese, chromium, copper, nickel, selenium, vanadium, titanium, germanium, molybdenum, silicon, iron, fluorine, silver, rubidium, tin, zirconium, cadmium, zinc, tungsten and aluminum. These ions may be provided, for example, in trace element salts, such as H₃BO₃, Ba(C₂H₃O₂)₂, KBr, COCl₂-6H₂O, KI, MnCl₂-2H₂O, Cr(SO₄)₃-15H₂O, CuSO₄-5H₂O, NiSO₄-6H₂O, H₂SeO₃, NaVO₃, TiCl₄, GeO₂, (NH₄)₆Mo₇O₂₄-4H₂O, Na₂SiO₃-9H₂O, FeSO₄-7H₂O, NaF, AgNO₃, RbCl, SnCl₂, ZrOCl₂-8H₂O, CdSO₄-8H₂O, ZnSO₄-7H₂O, Fe(NO₃)₃-9H₂O, Na₂WO₄, AlCl₃-6H₂O.

[0110] In some embodiments, the medium comprises one or more minerals selected from the group consisting of nickel, cobalt, sodium, magnesium, iron, copper, manganese, zinc, boron, phosphorus, sulfur, nitrogen, selenium, tungsten, aluminum and potassium including any suitable non-toxic salts thereof. Thus, in some embodiments, the minerals in the medium are provided as mineral salts. Any suitable salts or hydrates may be used to make the medium. For example, and in some embodiments, the media comprises one or more of the following mineral salts: Na₃nitrilotriacetate, nitrilotriacetic acid, NiCl₂-6H₂O, CoCl₂-6H₂O, Na₂MoO₄-H₂O, MgCl₂-6H₂O, FeSO₄-H₂O, Na₂SeO₃, Na₂WO₄, KH₂PO₄, and NaCl. In some embodiments, L-cysteine may be added as a redox buffer to support early phases of growth of a low-density culture. In some embodiments, the medium comprises nickel, optionally NiCl₂-6H₂O in an amount of about 0.001 mM to about 0.01 mM, e.g. 0.002 mM, 0.003 mM, 0.004 mM, 0.005 mM, 0.006 mM, 0.007 mM, 0.008 mM, 0.009 mM, or any combination of the foregoing range endpoints. In some embodiments, the media comprises a nitrogen source, e.g., ammonium hydroxide or ammonium chloride in an amount of about 1 mM to about 10 mM, e.g. 2 mM, 3 mM, 4 mM, 5 mM, 6 mM, 7 mM, 8 mM, 9 mM, or any combination of the foregoing range endpoints. In some embodiments, the media comprises cobalt, e.g. CoCl₂-6H₂O, in an amount of about 0.001 mM to about 0.01 mM, e.g., 0.002 mM, 0.003 mM, 0.004 mM, 0.005 mM, 0.006 mM, 0.007 mM, 0.008 mM, 0.009 mM, or any combination of the foregoing range endpoints. In some embodiments, the media comprises molybdenum, a molybdenum source or molybdate, e.g. Na₂MoO₄-H₂O, in an amount of about 0.005 mM to about 0.05 mM, e.g., 0.006 mM, 0.007 mM, 0.008 mM, 0.009 mM, 0.01 mM, 0.02 mM, 0.03 mM, 0.04 mM, or any combination of the foregoing range endpoints. In some embodiments, the media comprises magnesium, e.g. MgCl₂-6H₂O, in an amount of about 0.5 mM to about 1.5 mM, e.g., 0.6 mM, 0.7 mM, 0.8 mM, 0.9 mM, 1.0 mM, 1.1 mM, 1.2 mM, 1.3 mM, 1.4 mM, or any combination of the foregoing range endpoints. In some embodiments, the media comprises iron, e.g. FeSO₄-H₂O, in an amount of about 0.05 mM to about 0.5 mM, e.g., 0.06 mM, 0.07 mM, 0.08 mM, 0.09 mM, 0.1 mM, 0.2 mM, 0.3 mM, 0.4 mM, or any combination of the foregoing range endpoints. In some embodiments, the media comprises a sulfur source or sulfate in an amount of about 0.05 mM to about 0.5 mM, e.g., 0.06 mM, 0.07 mM, 0.08 mM, 0.09 mM, 0.1 mM, 0.2 mM, 0.3 mM, 0.4 mM, or any combination of the foregoing range endpoints. In some embodiments, the media comprises selenium, a selenium source or selenate, e.g. Na₂SeO₃, in an amount of about 0.005 mM to about 0.05 mM, e.g., 0.006 mM, 0.007 mM, 0.008 mM, 0.009 mM, 0.01 mM, 0.02 mM, 0.03 mM, 0.04 mM, or any combination of the foregoing range endpoints. In some embodiments, the media comprises tungsten, a tungsten source or tungstate, e.g. Na₂WO₄, in an amount of about 0.005 mM to about

0.05 mM, e.g., 0.006 mM, 0.007 mM, 0.008 mM, 0.009 mM, 0.01 mM, 0.02 mM, 0.03 mM, 0.04 mM, or any combination of the foregoing range endpoints. In some embodiments, the media comprises potassium, e.g. KH₂PO₄, in an amount of about 5 mM to about 15 mM, e.g., 6 mM, 7 mM, 8 mM, 9 mM, 10 mM, 11 mM, 12 mM, 13 mM, 14 mM, or any combination of the foregoing range endpoints. In some embodiments, the media comprises phosphorus, a phosphorus source, or phosphate, e.g. KH₂PO₄, in an amount of about 5 mM to about 15 mM, e.g., 6 mM, 7 mM, 8 mM, 9 mM, 10 mM, 11 mM, 12 mM, 13 mM, 14 mM, or any combination of the foregoing range endpoints. In some embodiments, the media comprises NaCl in an amount of about 5 mM to about 15 mM, e.g., 6 mM, 7 mM, 8 mM, 9 mM, 10 mM, 11 mM, 12 mM, 13 mM, 14 mM, or any combination of the foregoing range endpoints.

[0111] Some archaea are extreme halophiles and prefer high salt conditions, e.g. about 1.5M to about 5.5 M NaCl, or about 3 M to about 4 M NaCl. Other archaea may be adapted to growth in higher salt conditions than their normal environment.

[0112] In some embodiments, the culture medium serves more than one purpose. Accordingly, in some aspects, the culture medium supports the growth and/or survival of the microorganisms of the culture and serves as the cathode electrolytic medium within the reactor. An electrolyte is a substance that, when dissolved in water, permits current to flow through the solution. The conductivity (or specific conductance) of an electrolytic medium is a measure of its ability to conduct electricity. The SI unit of conductivity is siemens per meter (S/m), and unless otherwise qualified, it is measured at a standard temperature of 25 °C. Deionized water may have a conductivity of about 5.5 μS/m, while sea water has a conductivity of about 5 S/m (i.e., sea water's conductivity is one million times higher than that of deionized water).

[0113] Conductivity is traditionally determined by measuring the AC resistance of the solution between two electrodes or by torroidal inductance meters.

[0114] Limiting ion conductivity in water at 298 K for exemplary ions:

Cations	λ+0 /mS m ² mol ⁻¹	anions	λ-0 /mS m ² mol ⁻¹
H ⁺	34.96	OH	19.91
Li ⁺	3.869	Cl	7.634
Na ⁺	5.011	Br	7.84
K ⁺	7.350	I	7.68
Mg ²⁺	10.612	SO42	15.96
Ca ²⁺	11.900	NO ₃	7.14

[0115] In some embodiments, the culture medium comprises a high salt concentration for purposes of increasing the conductivity of the culture medium/reactor cathode electrolyte. Conductivity is readily adjusted, for example, by adding NaCl until the desired conductivity is achieved. In some embodiments, the conductivity of the medium/electrolyte is in the range of 1 to 25 S/m (0.01 to 0.25 S/cm). This conductivity is readily achieved within the range of salt concentrations that are compatible with living methanogenic Archaea.

Vitamins

[0116] In some embodiments, vitamins are substantially absent from the culture medium, to reduce contamination by non-methanogens and/or to decrease the cost of the culture medium, and thus, the overall cost of the biological reactor. However, it is possible to operate the biological reactor using media supplemented with one or more vitamins selected from the group consisting of ascorbic acid, biotin, choline chloride; D-Ca⁺⁺pantothenate, folic acid, i-inositol, menadione, niacinamide, nicotinic acid, paraaminobenzoic acid (PABA), pyridoxal, pyridoxine, riboflavin, thiamine-HCl, vitamin A acetate, vitamin B₁₂ and vitamin D₂. In some embodiments, the medium is supplemented with a vitamin that is essential to survival of the methanogenic microorganism, but other vitamins are substantially absent.

Other materials

[0117] The culture medium in some embodiments comprises materials other than inorganic compounds and salts. For example, the culture medium in some embodiments, comprises a chelating agent. Suitable chelating agents are known in the art and include but not limited to nitrilotriacetic acid and/or salts thereof. Also, in some aspects, the culture medium comprises a redox buffer, e.g., Cys, to support an early active growth phase in a low-density culture.

Carbon Sources

[0118] In some aspects, the culture medium comprises a carbon source, e.g., carbon dioxide, formate, or carbon monoxide. In some embodiments, the culture medium comprises a plurality of these carbon sources in combination. Preferably, organic carbon sources are substantially absent, to reduce contamination by non-methanogens.

Nitrogen Sources

[0119] In some embodiments, the culture medium comprises a nitrogen source, e.g., ammonium, anhydrous ammonia, ammonium salts and the like. In some embodiments, the culture medium may comprise nitrate or nitrite salts as a nitrogen source, although chemically reduced nitrogen compounds are preferable. In some aspects, the culture medium substantially lacks an organic nitrogen source, e.g., urea, corn steep liquor, casein, peptone yeast extract, and meat extract. In some embodiments diatomic nitrogen (N_2) may serve as a nitrogen source, either alone or in combination with other nitrogen sources.

Oxygen

[0120] Methanogens that are primarily anaerobic may still be capable of surviving prolonged periods of oxygen stress, e.g. exposure to ambient air for at least 6, 12, 18, or 24 hours, or 2 days, 3 days, 4 days, 5 days, 6 days, 1 week or more. Ideally, exposure to air is for 4 days or less, or 3 days or less, or 2 days or less, or 24 hours or less. Methane production may continue in the presence of oxygen concentrations as high as 2-3% of the gas phase for extended periods (at least days). However, anaerobic organisms will grow optimally in conditions of low oxygen. In some embodiments, the biological reactor substantially excludes oxygen to promote high levels of methane production.

[0121] In some embodiments, the system comprises various methods and/or features that reduce the presence of oxygen in the CO_2 stream that is fed into the biological reactor. When obligate anaerobic methanogenic microorganisms are used to catalyze methane formation, the presence of oxygen may be detrimental to the performance of the process and contaminates the product gas. Therefore, reduction of the presence of oxygen in the CO_2 stream is helpful for improving the process. In one embodiment, the oxygen is removed by pre-treatment of the gas stream in a biological reactor. In this embodiment, the reductant may be provided either by provision of a source of organic material (e.g. glucose, starch, cellulose, fermentation residue from an ethanol plant, whey residue, etc.) that can serve as substrate for an oxidative fermentation. The microbial biological catalyst is chosen to oxidatively ferment the chosen organic source, yielding CO_2 from the contaminant oxygen. In another embodiment, oxygen removal is accomplished in the main fermentation vessel via a mixed culture of microbes that includes one capable of oxidative fermentation of an added organic source in addition to the autotrophic methanogen necessary for methane production. An example of a suitable mixed culture was originally isolated as "Methanobacillus omelianskii" and is readily obtained from environmental sources (Bryant et al. Archiv Microbiol 59:20-31 (1967) "Methanobacillus omelianskii, a symbiotic association of two species of bacteria."). In another embodiment, carbon dioxide in the input gas stream is purified away from contaminating gases, including oxygen, by selective absorption or by membrane separation. Methods for preparing carbon dioxide sufficiently free of oxygen are well known in the art.

Exemplary media

[0122] In some embodiments, the culture medium comprises the following components: Na_3 nitrilotriacetate, nitrilotriacetic acid, $NiCl_2 \cdot 6H_2O$, $CoCl_2 \cdot 6H_2O$, $Na_2MoO_4 \cdot H_2O$, $MgCl_2 \cdot 6H_2O$, $FeSO_4 \cdot H_2O$, Na_2SeO_3 , Na_2WO_4 , KH_2PO_4 , and $NaCl$. In some embodiments, L-cysteine may be added as a redox buffer to support early phases of growth of a low-density culture. In some embodiments, the media comprises Na_3 nitrilotriacetate (0.81 mM), nitrilotriacetic acid (0.4 mM), $NiCl_2 \cdot 6H_2O$ (0.005 mM), $CoCl_2 \cdot 6H_2O$ (0.0025 mM), $Na_2MoO_4 \cdot H_2O$ (0.0025 mM), $MgCl_2 \cdot 6H_2O$ (1.0 mM), $FeSO_4 \cdot H_2O$ (0.2 mM), Na_2SeO_3 (0.001 mM), Na_2WO_4 (0.01 mM), KH_2PO_4 (10 mM), and $NaCl$ (10 mM). L-cysteine (0.2 mM) may be included.

[0123] In some embodiments, the culture medium comprises the following components: KH_2PO_4 , NH_4Cl , $NaCl$, Na_3 nitrilotriacetate, $NiCl_2 \cdot 6H_2O$, $CoCl_2 \cdot H_2O$, $Na_2MoO_4 \cdot 2H_2O$, $FeSO_4 \cdot 7H_2O$, $MgCl_2 \cdot 6H_2O$, Na_2SeO_3 , Na_2WO_4 , $Na_2S \cdot 9H_2O$. A culture medium comprising these components may be referred to herein as Medium 1, which is capable of supporting survival and/or growth of methanogenic microorganisms originally derived from a terrestrial environment, e.g., *aMethanothermobacter* species. Thus, in some embodiments, the biological reactor comprises a culture of *Methanothermobacter* and a culture medium of Medium 1. In some aspects, the culture medium is adjusted with NH_4OH to a pH between about 6.8 and about 7.3. In some embodiments, the culture medium not only supports growth of and/or survival of and/or methane production by the methanogenic microorganisms but also serves as the cathode electrolytic medium suitable for conducting electricity within the reactor. Accordingly, in some aspects, the conductivity of the culture

medium is in the range of about 1 to about 25 S/m (about 0.01 to about 0.25 S/cm).

[0124] In some embodiments, the KH_2PO_4 is present in the medium at a concentration within the range of about 1 mM to about 100 mM, e.g., about 2 mM, about 50 mM, about 5 mM to about 20 mM.

[0125] In some embodiments, the NH_4Cl is present in the culture medium at a concentration within the range of about 10 mM to about 1500 mM, e.g., about 20 mM to about 600 mM, about 60 mM to about 250 mM.

[0126] In some embodiments, the NaCl is present in the culture medium within the range of about 1 mM to about 100 mM, e.g., about 2 mM, about 50 mM, about 5 mM to about 20 mM.

[0127] In some embodiments, the $\text{Na}_3\text{nitrilotriacetate}$ is present in the culture medium within the range of about 0.1 mM to about 10 mM, e.g., 0.20 mM to about 6 mM, about 0.5 to about 2.5 mM.

[0128] In some embodiments, the $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$ is present in the culture medium within the range of about 0.00025 to about 0.025 mM, e.g., about 0.005 mM to about 0.0125 mM, about 0.0005 mM to about 0.005 mM.

[0129] In some embodiments, the $\text{COCl}_2 \cdot \text{H}_2\text{O}$ is present in the culture medium within the range of about 0.0005 mM to about 0.05 mM, e.g., about 0.001 mM to about 0.025 mM, about 0.0025 mM to about 0.01 mM.

[0130] In some embodiments, the $\text{Na}_2\text{MoO}_4 \cdot 2\text{H}_2\text{O}$ is present in the culture medium within the range of about 0.00025 mM to about 0.025 mM, e.g., about 0.0005 mM to about 0.0125 mM, about 0.00125 mM to about 0.005 mM.

[0131] In some embodiments, the $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ is present in the culture medium within the range of about 0.02 mM to about 2 mM, e.g., about 0.04 mM to about 1 mM, about 0.1 mM to about 0.4 mM.

[0132] In some embodiments, the $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ is present in the culture medium within the range of about 0.1 mM to about 10 mM, e.g., about 0.2 mM to about 5 mM, about 0.5 mM to about 2 mM.

[0133] In some embodiments, the Na_2SeO_3 is present in the culture medium within the range of about 0.0001 mM to about 0.01 mM, e.g., about 0.0002 mM to about 0.005 mM, about 0.0005 mM to about 0.002 mM.

[0134] In some embodiments, the Na_2WO_4 is present in the culture medium within the range of about 0.001 mM to about 0.1 mM, e.g., about 0.05 mM to about 0.05 mM, about 0.005 mM to about 0.02 mM.

[0135] In some embodiments, Medium 1 is supplemented with components, such as sulfide, that support the active growth phase or relatively rapid multiplication of the microorganism. Accordingly, in some aspects, the culture medium comprises a higher sulfide concentration, e.g. 0.1 mM to about 10 mM (e.g., about 0.2 mM to about 5 mM, about 0.5 mM to about 2 mM), about 0.5 to 5 mM, or about 1 mM $\text{Na}_2\text{S} \cdot 9\text{H}_2\text{O}$, and preferably greater than 0.01 mM $\text{Na}_2\text{S} \cdot 9\text{H}_2\text{O}$, optionally with a pH between about 6.8 and about 7.0. In other embodiments, Medium 1 supports the inactive or stationary or nearly-stationary growth phase of the microorganism and the medium comprises a lower sulfide concentration. Accordingly, in some aspects, the culture comprises about 0.01 mM or less $\text{Na}_2\text{S} \cdot 9\text{H}_2\text{O}$, and not 1 mM $\text{Na}_2\text{S} \cdot 9\text{H}_2\text{O}$, optionally with a pH between about 7.2 and about 7.4.

[0136] In some embodiments, the culture medium comprises the following components: KH_2PO_4 , NaCl , NH_4Cl , Na_2CO_3 , $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$, $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$, $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$, $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$, $\text{Na}_2\text{SeO}_3 \cdot 5\text{H}_2\text{O}$, $\text{Na}_2\text{WO}_4 \cdot \text{H}_2\text{O}$, $\text{MnCl}_2 \cdot 4\text{H}_2\text{O}$, ZnCl_2 , H_3BO_3 , $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$, $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$, $\text{Na}_2\text{MoO}_4 \cdot 2\text{H}_2\text{O}$, Nitrilotriacetic acid, $\text{Na}_3\text{nitrilotriacetic acid}$, $\text{KAl}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$, $\text{Na}_2\text{S} \cdot 9\text{H}_2\text{O}$. A culture medium comprising these components may be referred to herein as Medium 2, which is capable of supporting survival and/or growth of methanogenic microorganisms originally derived from a marine environment, e.g., a *Methanocaldococcus* species, *Methanotorris* species, *Methanopyrus* species, or *Methanothermococcus* species. In some aspects, the culture medium is adjusted with NH_4OH to a pH between about 6.3 and about 6.8 (e.g., about 6.4 to about 6.6). In some embodiments, the culture medium not only supports growth of and/or survival of and/or methane production by the methanogenic microorganisms but also serves as the cathode electrolytic medium suitable for conducting electricity within the reactor. Accordingly, in some aspects, the conductivity of the culture medium is in the range of about 1 to about 25 S/m (about 0.01 to about 0.25 S/cm).

[0137] In some embodiments, the KH_2PO_4 is present in the culture medium at a concentration within the range of about 0.35 mM to about 37 mM, e.g., about 0.7 mM to about 0.75 mM, about 1.75 mM to about 7.5 mM.

[0138] In some embodiments, the NaCl is present in the culture medium at a concentration within the range of about 17 mM to about 1750 mM, e.g., about 30 mM to about 860 mM, about 80 mM to about 350 mM.

[0139] In some embodiments, the NH_4Cl is present in the culture medium at a concentration within the range of about 0.7 mM to about 750 mM, e.g., about 1.5 mM to about 40 mM, about 3.75 mM to about 15 mM.

[0140] In some embodiments, the Na_2CO_3 is present in the culture medium at a concentration within the range of about 5 mM to about 600 mM, e.g., 10 mM to about 300 mM, about 30 mM to about 150 mM.

[0141] In some embodiments, the $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ is present in the culture medium at a concentration within the range of about 0.05 to about 50 mM, e.g., 0.2 mM to about 5 mM, about 0.5 mM to about 2 mM.

[0142] In some embodiments, the $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ is present in the culture medium at a concentration within the range of about 3 mM to about 350 mM, e.g., about 6.5 mM to about 175 mM, about 15 mM to about 70 mM.

[0143] In some embodiments, the $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$ is present in the culture medium at a concentration within the range of about 0.003 mM to about 0.3 mM, e.g., about 0.006 mM to about 0.15 mM, about 0.015 mM to about 0.06 mM.

[0144] In some embodiments, the $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$ is present in the culture medium at a concentration within the range of about 0.0005 mM to about 0.007 mM, e.g., 0.0012 mM to about 0.03 mM, about 0.003 mM to about 0.012 mM.

[0145] In some embodiments, the $\text{Na}_2\text{SeO}_3 \times 5 \text{H}_2\text{O}$ is present in the culture medium at a concentration within the range of about 0.0001 mM to about 0.01 mM, e.g., about 0.00025 mM to about 0.01 mM, about 0.001 mM to about 0.005 mM.

[0146] In some embodiments, the $\text{Na}_2\text{WO}_4 \times \text{H}_2\text{O}$ is present in the culture medium at a concentration within the range of about 0.0005 mM to about 0.007 mM, e.g., 0.0012 mM to about 0.03 mM, about 0.003 mM to about 0.012 mM.

[0147] In some embodiments, the $\text{MnCl}_2 \times 4\text{H}_2\text{O}$ is present in the culture medium at a concentration within the range of about 0.003 mM to about 0.4 mM, e.g., about 0.08 mM to about 2 mM, about 0.02 mM to about 0.08 mM.

[0148] In some embodiments, the ZnCl_2 is present in the culture medium at a concentration within the range of about 0.0005 mM to about 0.007 mM, e.g., 0.0012 mM to about 0.03 mM, about 0.003 mM to about 0.012 mM.

[0149] In some embodiments, the H_3BO_3 is present in the culture medium at a concentration within the range of about 0.0001 mM to about 0.01 mM, e.g., about 0.00025 mM to about 0.01 mM, about 0.001 mM to about 0.005 mM.

[0150] In some embodiments, the $\text{COCl}_2 \times 6\text{H}_2\text{O}$ is present in the culture medium at a concentration within the range of about 0.0005 mM to about 0.007 mM, e.g., 0.0012 mM to about 0.03 mM, about 0.003 mM to about 0.012 mM.

[0151] In some embodiments, the $\text{CuCl}_2 \times 2\text{H}_2\text{O}$ is present in the culture medium at a concentration within the range of about 0.00004 mM to about 0.004 mM, e.g., 0.00008 mM to about 0.002 mM, about 0.0002 mM to about 0.0008 mM.

[0152] In some embodiments, the $\text{Na}_2\text{MoO}_4 \times 2\text{H}_2\text{O}$ is present in the culture medium at a concentration within the range of about 0.00004 mM to about 0.004 mM, e.g., 0.00008 mM to about 0.002 mM, about 0.0002 mM to about 0.0008 mM.

[0153] In some embodiments, the Nitrilotriacetic acid is present in the culture medium at a concentration within the range of about 0.003 mM to about 0.7 mM, e.g., about 0.12 mM to about 0.3 mM, about 0.03 mM to about 0.12 mM.

[0154] In some embodiments, the Na_3 nitrilotriacetic acid is present in the culture medium at a concentration within the range of about 0.002 mM to about 0.2 mM, e.g., about 0.004 mM to about 0.1 mM, about 0.01 mM to about 0.04 mM.

[0155] In some embodiments, the $\text{KAl}(\text{SO}_4)_2 \times 12 \text{H}_2\text{O}$ is present in the culture medium at a concentration within the range of about 0.00004 mM to about 0.004 mM, e.g., 0.00008 mM to about 0.002 mM, about 0.0002 mM to about 0.0008 mM.

[0156] In some embodiments, the salt concentration in Medium 2 is adjusted upward to the range of 400 to 800 mM for formulation of the electrolyte in the reactor. Additionally, the sulfide concentration of relatively stationary cultures is adjusted downward to the range of <0.01mM (<1ppm sulfide in the exit gas stream).

[0157] In some examples, the media is sparged with a $\text{H}_2\text{:CO}_2$ gas mixture in a 4:1 ratio. The gas mixture can, in some embodiments, be generated with mass flow controllers at a total flow of 250 ml/minute. In some embodiments, the medium should be replenished at a rate suitable to maintain a useful concentration of essential minerals and to eliminate any metabolic products that may inhibit methanogenesis. Dilution rates below 0.1 culture volume per hour are suitable, since they yield high volumetric concentrations of active methane generation capacity.

Culture Conditions

Temperature

[0158] It is also disclosed that the temperature of the culture is maintained near the optimum temperature for growth of the organism used in the culture (e.g. about 35°C to about 37°C for mesophilic organisms such as *Methanosarcinia barkeri* and *Methanococcus maripaludis* or about 60°C to about 65°C for thermophiles such as *Methanothermobacter thermoautotrophicus*, and about 85°C to about 90°C for organisms such as *Methanocaldococcus jannaschii*, *Methanocaldococcus fervens*, *Methanocaldococcus indicus*, *Methanocaldococcus infernus*, and *Methanocaldococcus vulcanius*). However, it is envisioned that temperatures above or below the temperatures for optimal growth may be used. In fact, higher conversion rates of methane may be obtained at temperatures above the optimal growth rate temperature. Temperatures of 50 °C or higher are contemplated, e.g., 51 °C or higher, 52 °C or higher, 53°C or higher, 54 °C or higher, 55 °C or higher, 56°C or higher, 57 °C or higher, 58 °C or higher, 59 °C or higher, 60°C to 150°C, 60°C to 120°C, 60°C to 100°C, 60°C to 80°C. Temperatures of 50°C or higher are contemplated, e.g. 50°C to 150°C, 50°C to 120°C, or 50°C to 100°C.

[0159] In view of the foregoing, the temperature at which the culture is maintained may be considered as a description of the methanogenic microorganisms contemplated herein. For example, when the temperature of the culture is maintained at a temperature between 55 °C and 120°C, the methanogenic microorganism is considered as one that can be cultured at this temperature. Accordingly, the methanogenic microorganism in some embodiments is a thermophile or a hyperthermophile. In some aspects, the culture of the biological reactor comprises an autotrophic thermophilic methanogenic microorganism or an autotrophic hyperthermophilic methanogenic microorganism. In some aspects, the culture of the biological reactor comprises an autotrophic thermophilic methanogenic microorganism or an autotrophic hyperthermophilic methanogenic microorganism, either of which is tolerant to high conductivity culture medium (e.g., about 1 to about 25 S/m), as described herein, e.g., a halophile.

[0160] Archaea may be capable of surviving extended periods at suboptimal temperatures. In some embodiments, a culture of archaea can naturally survive or are adapted to survive at room temperature (e.g. 22-28 °C) for a period of at least 3 weeks to 1, 2, 3, 4, 5 or 6 months.

[0161] In some embodiments, the organisms in the culture are not mesophilic. In some embodiments, the culture is not maintained at a temperature below or about 37 °C. With respect to thermophilic organisms (including, but not limited to, *Methanothermobacter thermoautotrophicus*, *Methanocaldococcus jannaschii*, *Methanocaldococcus fervens*, *Methanocaldococcus indicus*, *Methanocaldococcus infernus*, and *Methanocaldococcus vulcanius*), in some embodiments, the temperature of the culture is e.g. about 60°C to about 150°C, about 60°C to about 120°C, about 60°C to about 100°C, or about 60°C to about 80°C.

pH

[0162] Archaea can also survive under a wide range of pH conditions. In some embodiments, the pH of the culture comprising methanogenic microorganisms is between about 3.5 and about 10.0, although for growth conditions, the pH may be between about 6.5 and about 7.5. For example, the pH of the culture may be about 3.5, about 3.6., about 3.7, about 3.8, about 3.9, about 4.0, about 4.5, about 5.0, about 5.5, about 6.0, about 6.5, about 7.0, about 7.5, about 8.0, about 8.5, about 9.0, about 9.5, about 10.0. In some embodiments, the pH of the media is acidic, e.g. about 0.1 to about 5.5, about 0.1 to about 4, about 0.1 to about 3, about 1 to about 3, or about 2 to about 3. In some embodiments, the pH of the media is close to neutral, e.g. about 6 to about 8. In some embodiments, the pH of the media is alkaline, e.g. about 8.5 to about 11, or about 8 to about 10. The pH of the media can be altered by means known in the art. For example, the pH can be controlled by sparging CO₂ and/or by adding acid (e.g., HCL) or base (e.g., NaOH or NH₄OH) as needed.

Pressure

[0163] In some embodiments, suitably pressures within the biological reactor range from about 0.5 atmospheres to about 500 atmospheres. The biological reactor can also contain a source of intermittent agitation of the culture. Also in one embodiment, the methane gas removed from the biological reactor suitably comprises less than about 450 ppm hydrogen sulfide, or alternatively less than about 400 ppm, 300 ppm, 200 ppm, 150 ppm, 100 ppm, 50 ppm or 20 ppm of hydrogen sulfide. Total gas delivery rates (CO₂) in the range of 0.2 to 4 volume of gas (STP) per volume of culture per minute are suitable, since they both maintain and exploit high volumetric concentrations of active methane generation capacity. In one embodiment, the redox potential is maintained below -100 mV or lower during methanogenesis. The method of the present invention encompasses conditions in which the redox potential is transiently increased to above -100 MV, as for example when air is added to the system.

Culture Containers

[0164] A biological reactor, also known as a fermentor vessel, bioreactor, or simply reactor, as set forth herein may be any suitable vessel in which methanogenesis can take place. Suitable biological reactors to be used in the present invention should be sized relative to the volume of the CO₂ source. Typical streams of 2,200,000 1b CO₂/day from a 100,000,000 gal/yr ethanol plant would require a CO₂ recovery/methane production fermentor of about 750,000 gal total capacity. Fermentor vessels similar to the 750,000 gal individual fermentor units installed in such an ethanol plant would be suitable.

Culture Volume and Density

[0165] The concentration of living cells in the culture medium (culture density) is in some embodiments maintained above 1 g dry weight/L. In certain embodiments, the density may be 30 g dry weight/L or higher. The volume of the culture is based upon the pore volume within the porous cathode structure within the reactor, plus any volume needed to fill any ancillary components of the reactor system, such as pumps and liquid/gas separators.

Culture Medium For Reducing Contamination By Non-Methanogens

[0166] The term "non-methanogen" as used herein refers to any microorganism that is not a methanogen or is not a host cell expressing genes that permit methanogenesis. For example, in some embodiments, the archaea are cultured under conditions wherein the temperature, pH, salinity, sulfide concentration, carbon source, hydrogen concentration or electric source is altered such that growth of non-methanogens is significantly retarded under such conditions. The methanogens are cultured at a temperature that is at least 50 °C or higher, as discussed herein, e.g., 100°C or more,

to avoid contamination by mesophilic non-methanogens. In other embodiments, the methanogens are cultured under conditions of high salinity (e.g., >75%) to avoid contamination by non-methanogens that are not capable of growing under high salt conditions. In still other embodiments, the methanogens are cultured under conditions in which the pH of the culture media is altered to be more acidic or more basic in order to reduce or eliminate contamination by non-methanogens that are not capable of growing under such conditions.

[0167] Contamination by non-methanogens can also be accomplished by minimizing amounts of organic carbon nutrients (e.g., sugars, fatty acids, oils, etc.) in the media. For example, in some embodiments, organic nutrients are substantially absent from the medium.

[0168] In some embodiments, components required for the growth of non-methanogenic organisms are substantially absent from the media. Such components include, but are not limited to, one or more organic carbon sources, and/or one or more organic nitrogen sources, and/or one or more vitamins. In some embodiments, formate, acetate, ethanol, methanol, methylamine, and any other metabolically available organic materials are substantially absent from the media.

[0169] In some embodiments, high salt conditions that permit survival of methanogens can retard growth of contaminating organisms.

[0170] In some embodiments, high temperatures that permit survival of methanogens can retard growth of contaminating organisms.

[0171] The term "substantially lacks" or "substantially absent" or "substantially excludes" as used herein refers to the qualitative condition of lacking an amount of a particular component significant enough to contribute to the desired function (e.g. growth of microorganisms, production of methane). In some embodiments, the term "substantially lacks" when applied to a given component of the media means that the media contains less than 5%, 4%, 3%, 2%, 1%, 0.9%, 0.8%, 0.7%, 0.6%, 0.5%, 0.4%, 0.3%, 0.2%, 0.1% or less of that component. In some embodiments, the media does not contain detectable amounts of a given component.

Kits

[0172] The present disclosure further provides kits comprising any one or a combination of: a culture comprising methanogenic microorganisms, a reactor, and a culture medium. The culture of the kit may be in accordance with any of the teachings on cultures described herein. The kit may comprise a culture comprising an adapted strain of methanogenic microorganisms that are capable of growth and/or survival under high temperature conditions (i.e. above 50 °C, as further described herein), high salt or high conductivity conditions (as further described herein). The kit may comprise only the methanogenic microorganisms. The culture medium of the kits may be in accordance with any of the teachings on culture medium described herein. The kit may comprise a culture medium comprising the components of Medium 1 or comprising the components of Medium 2, as described herein. The kit may comprise only the culture medium. In certain of these aspects, the kit may comprise the reactor comprising an anode and cathode. The reactor may be in accordance with any of the teachings of reactors described herein.

III. Implementations and Applications of the System

[0173] The biological reactor used in the methods for producing methane according to the claims may be used in a variety of implementations or applications, such as are illustrated in Figs. 13 and 14.

[0174] For example, a biological reactor may be used as part of a stand-alone system 500, as illustrated in Fig. 13. The system 500 may be used to provide multiple energy sources (e.g., electricity and methane), or to store electrical energy produced during favorable conditions as other energy resources (e.g., methane) for use when electrical energy cannot be generated at required levels. Such a stand-alone system 500 may be particularly useful in processing spatially or temporally stranded electricity where or when this electricity does not have preferable markets.

[0175] The system 500 may include a biological reactor 502 coupled to one or more electricity sources, for example a carbon-based power plant (e.g., coal-fired power plant, natural gas-fired power plant, or biomass-fired power plant) 504, a wind-powered turbine 506, water-powered turbine 508, a fuel cell 510, solar thermal system 512 or photovoltaic system 514, or a nuclear power plant 516. It will be recognized that other sources of electricity (e.g., a geothermal power source, or a capacitor or super capacitor used for energy storage) may be used in addition to or in substitution for those illustrated. The biological reactor 502 may be coupled directly to carbon-based power plant 504, nuclear power plant 516, or other power plant that may not be able to ramp power production up or down without significant costs and/or delays, and in such a system the biological reactor 502 uses surplus electricity to convert carbon dioxide into methane that can be used in a generator to produce sufficient electricity to meet additional demands. The biological reactor 502 may use surplus electricity (electricity that is not needed for other purposes) generated by one or more of the sources 506, 508, 510, 512, 514 to convert carbon dioxide into methane to be used in a generator to produce electricity when wind, water, solar or other conditions are unfavorable to produce electricity or to produce sufficient electricity to meet demands.

[0176] As is also illustrated in Fig. 13, the biological reactor 502 may be coupled to one or more carbon dioxide sources, for example one or more carbon-based power plants (e.g., coal-fired power plant, natural gas-fired power plant, biomass-fired power plant, or carbon-based fuel cells, which may be used as heating and power co-generation facilities or as dedicated factory power facilities) 520, which plants may be the same as or different from the plant 504. Alternatively, the stand-alone system 500 may be disposed in the vicinity of an industrial plant that provides carbon dioxide as an byproduct or a waste product, including ethanol manufacturing plants (e.g., fuel ethanol fermentation facilities) 522, industrial manufacturing plants (e.g., cement manufacturing plants or chemical manufacturing facilities) 524, commercial manufacturing plants (e.g., breweries) 526, and petrochemical refineries 528. While such significant point source emissions may serve well as a source of carbon dioxide for the biological reactor 502, it may also be possible to use atmospheric sources 530 as well (by using a carbon dioxide adsorption/desorption systems to capture atmospheric carbon dioxide, for example). As a further alternative, the carbon dioxide may be stored for use in the biological reactor (e.g., a stored source 532).

[0177] Where a significant point source of emissions is used as the carbon dioxide source (e.g., sources 520, 522, 524, 526, 528), the carbon dioxide emissions may be diverted into the biological reactor 502 to produce methane when electric power is available at prices below a pre-determined threshold. When electric power is above the pre-determined threshold, the carbon dioxide emissions may instead be emitted to the atmosphere, or it may be stored (as represented by the source 532) for later utilization in the biological reactor 502.

[0178] The carbon dioxide from a point emission source may be commingled with other gases, including carbon monoxide, hydrogen, hydrogen sulfide, nitrogen, or oxygen or other gases common to industrial processes, or it may be substantially pure. The mixture of gases can be delivered directly to the biological reactor 502, or the carbon dioxide may be separated from the gaseous mixture before delivery to the biological reactor 502. Such sources of mixed gases include landfills, trash-to-energy facilities, municipal or industrial solid waste facilities, anaerobic digesters, concentrated animal feeding operations, natural gas wells, and facilities for purifying natural gas, which sources may be considered along side the illustrated sources 520, 522, 524, 526, 528, 530, 532.

[0179] In operation, electricity and carbon dioxide may be delivered to the biological reactor 502 continuously to maintain a desired output of methane. Alternatively, the delivery rate of the electrical current, the carbon dioxide, or water to the biological reactor 502 may be varied which may cause the rate of methane production to vary. The variations in electrical current, carbon dioxide, and water may vary according to design (to modulate the rate of methane production in response to greater or lesser demand) or as the availability of these inputs varies.

[0180] As is also illustrated in Fig. 13, the system 500 may include certain post-processing equipment 540 associated with the biological reactor 502. For example, depending on the nature of the biological reactor 502, the flow of material exiting the first (cathode) chamber may be sent to a liquid-gas separator. Alternatively, it may be necessary to process the methane from a gaseous form into a liquid form, which may be more convenient for purposes of storage or transport. The gas may need to be filtered to remove byproducts, which byproducts may be stored or transported separately or may be disposed of as waste material. In any event, the methane produced by the biological reactor may be sent to a storage site 550, or optionally to a distribution or transportation system 552 such as is discussed in detail with reference to the system illustrated in Fig. 14. The methane may also be used locally, for example to replace natural gas in local operations for heat, or in chemical production.

[0181] It will be recognized that while the discussion has focused on methane as the primary product of the reactor 502, the reactor 502 also will produce oxygen, which may be referred to as a secondary product or as a byproduct. Oxygen may be stored or transported in the same fashion as methane, and as such a parallel storage site and/or distribution system may be established for the oxygen generated as well. As one such example, the oxygen may be used locally, for example to enhance the efficiency of combustion and/or fuel cell energy conversion.

[0182] In the alternative to a stand-alone implementation, an integrated system 600 may be provided wherein a reactor 602 is coupled to an electrical power distribution grid 604, or power grid for short, as illustrated in Fig. 14. The power grid 604 may connect to a source of electricity 606, for example one or more power plants discussed above, such as a carbon-based power plant (e.g., coal-fired power plant, natural gas-fired power plant, or biomass-fired power plant), a wind-powered turbine, water-powered turbine, a fuel cell, solar thermal system or photovoltaic system, or a nuclear power plant. These plants 606 may be connected, via transmission substations 608 and high-voltage transmission lines 610, to power substations 612 and associated local distribution grids 614. A local distribution grid 614 may be connected to one or more biological reactors 602 according to the present disclosure via an induction circuit 616.

[0183] As noted above, certain of these power plants, such as those combusting the carbon-based fuels, operate most efficiently at steady state (i.e., ramping power production up or down causes significant costs and/or delays). The power grid may also be connected to power plants that have a variable output, such as the wind-powered and water-powered turbines and the solar-thermal and photovoltaic systems. Additionally, power users have variable demand. As such, the electricity that power producers with the lowest marginal operating expenses desire to supply to the grid 604 can, and typically does, exceed demand during extended periods (so called off-peak periods). During those periods, the excess capacity can be used by one or more biological reactors 602 according to the present disclosure to produce methane.

[0184] As also noted above, the biological reactor 602 may be coupled to one or more carbon dioxide sources 620, for example including carbon-based power plants (e.g., coal-fired power plant, natural gas-fired power plant, biomass-fired power plant, or carbon-based fuel cells). Alternatively, the system 600 may be disposed near an industrial plant that provides carbon dioxide as a byproduct or a waste product, or may use atmospheric sources of carbon dioxide or stored carbon dioxide. In fact, while it may be possible to have a readily available source of carbon dioxide for conversion into methane when off-peak electricity is also available, it might also be necessary to store carbon dioxide during non-off-peak (or peak) periods for later conversion when the electricity is available. For example, an industrial source of carbon dioxide may typically generate most of its carbon dioxide during daylight hours, which may coincide with the typical peak demand period for electricity, causing some manner of storage to be required so that sufficient carbon dioxide is available to be used in conjunction with off-peak electricity production. Simple and inexpensive, gas impermeable tanks may be sufficient for such storage for short periods of time, such as part of a day or for several days. As to such storage issues for longer periods or for larger volumes, considerable effort is presently being devoted to sequestration of carbon dioxide in underground storage sites, and it may be possible to utilize the sequestered carbon dioxide stored in such sites as the source 620 of carbon dioxide for use in the biological reactors 602 according to the present disclosure.

[0185] As was the case with the system 500, the system 600 may include optional post-processing equipment 630 that is used to separate or treat the methane produced in the reactor 602 as required. The methane may be directed from the biological reactor 602 (with or without post-processing) into one or more containment vessels 640. In fact, the methane may be stored in aboveground storage tanks, or transported via local or interstate natural gas pipelines to underground storage locations, or reservoirs, such as depleted gas reservoirs, aquifers, and salt caverns. Additionally, the methane may be liquefied for even more compact storage, in particular where the biological reactors 602 are located where a connection to a power grid and a source of carbon dioxide are readily available, but the connection to a natural gas pipeline is uneconomical.

[0186] It will be further noted from Fig. 14 that methane may be taken from storage 640 or sent directly from the reactor 602 (optionally via the post-processing equipment 630) to a methane collection subsystem 650. From the collection subsystem 650, the methane may be introduced into a transport system 652, which system 652 may be a system of local, interstate or international pipelines for the transportation of methane, or alternatively natural gas. In this regard, the methane produced by the reactor 602 may take advantage of existing infrastructure to transport the methane from its location of production to its location of consumption. The transportation system 652 may be coupled to a distribution subsystem 654 that further facilitates its transmission to the consumer 656, which consumer may be located remote from the biological reactor 602. The consumer 656 may even be one of the sources of electricity 606 connected to the power grid 604.

[0187] It will also be recognized that a biological reactor for producing methane may be useful in a closed atmospheric environment containing carbon dioxide or in which carbon dioxide is released by respiration, or other biological processes or by chemical reactions such as combustion or by a fuel cell. The biological reactor may be operating as a stand-alone implementation (as in Fig. 13) or as part of an integrated system (as in Fig. 14). The carbon dioxide in such an environment can be combined in the biological reactor with electrical current and water to produce methane and oxygen. Production of methane by this process may occur in a building sealed for containment purposes, or underground compartment, mine or cave or in submersible vehicle such as a submarine, or any other device or compartment that has limited access to external molecular oxygen, but sufficient electrical power, water and carbon dioxide to support the production of methane and oxygen. Oxygen produced by the biological reactor may likewise be stored as a gas, or liquefied for future use, sale or distribution.

[0188] While the foregoing examples have discussed the potential uses for methane produced by the biological reactor in meeting industrial, commercial, transportation, or residential needs (e.g., conversion into electricity through combustion in a carbon-based fuel generator or other uses, such as heating or cooking, non-combustion based conversion of methane into electricity such as via fuel cells, or chemical conversion into other compounds such as via halogenation, or reaction with other reactive species), it is also possible to appreciate the use of the biological reactor used in the method according to the claims, either in a stand-alone system or as connected to a power grid, as a mechanism for carbon capture. That is, separate and apart from its uses to provide an alternative energy resource, the biological reactors may be used to remove carbon dioxide from the atmosphere, where the carbon dioxide is produced by living microorganisms, by chemical oxidation of organic material or from combustion of carbon-based fossil fuels, in particular where the carbon dioxide may be produced by large point sources such as fossil fuel power plants, cement kilns or fermentation facilities. The conversion of carbon dioxide into methane thus may produce not only methane, which has multiple other uses, but the conversion of carbon dioxide according to the present disclosure may generate or earn carbon credits for the source of the carbon dioxide, in that the carbon dioxide production of the source is decreased. These carbon credits may then be used within a regulatory scheme to offset other activities undertaken by the carbon dioxide producer, or in the life cycle of the products used or sold by the carbon dioxide producer, such as for renewable fuels derived from biomass, or gasoline refined from crude petroleum or may be used within a trading scheme to produce a separate source of revenue.

Credits or offsets may be sold or conveyed in association with the methane, or oxygen, or other secondary products generated by the biological reactor or through the use of the biological reactor, or the credits may be traded independently such as on an exchange or sold directly to customers. In cases where the biological reactor functions within a business, or as part of a business contract with an entity, that uses oxygen, natural gas or methane from fossil or geologic sources, the methane produced by the biological reactor can be delivered to, or sold into a natural gas distribution system at times or in locations different from the use of natural gas and the business may retain any credits or offsets associated with the oxygen or methane produced with the biological reactor and apply such credit or offsets to natural gas or oxygen purchased from other sources and not produced directly by the biological reactor.

IV. Other Exemplary Embodiments

[0189] According to one embodiment, a method of converting carbon dioxide to methane according to claim 1 comprises a) preparing a culture of hydrogenotrophic methanogenic archaea, b) placing the culture of hydrogenotrophic methanogenic archaea in a cathode chamber of an electrolysis chamber, the electrolysis chamber having an anode and a cathode, the cathode situated in the cathode chamber, and the cathode and anode chambers separated by a selectively permeable barrier; c) supplying carbon dioxide to the cathode chamber of the electrolysis chamber; d) supplying water to the electrolysis chamber, and e) wherein the hydrogenotrophic methanogenic archaea utilize the electrons released by the cathode and convert the carbon dioxide to methane. Additionally, step e) of such a method may only result in the production of methane gas by the hydrogenotrophic methanogenic archaea and a separate stream of oxygen gas by the anode.

[0190] According to another embodiment, a method of converting carbon dioxide to methane according to claim 1 comprises a) preparing a culture of hydrogenotrophic methanogenic archaea; b) placing the culture of hydrogenotrophic methanogenic archaea in a cathode chamber of an electrolysis chamber, the electrolysis chamber having an anode chamber and a cathode chamber wherein the anode chamber has an anode and the cathode chamber has a cathode; c) supplying carbon dioxide to the electrolysis chamber; d) supplying water to the electrolysis chamber; e) wherein an electric potential difference is maintained between the cathode and the anode; and f) wherein the hydrogenotrophic methanogenic archaea utilize the electric potential difference between the cathode and the anode to convert the carbon dioxide to methane. According to such a method, the anode chamber and the cathode chamber may be separated by a selectively permeable barrier.

EXAMPLE 1

[0191] Vertical electrolysis chamber/cell configuration. A cylindrical electrolysis cell, 1.2 cm in internal diameter, was constructed from polysulfone plastic and arranged with an air-exposed anode on the bottom, covered by a Nafion 117 PEM and the closed cathode chamber on the top (Fig. 3). A Pt-carbon catalytic layer on a carbon mesh gas diffusion layer (GDE-LT) was used as the anode, with a titanium ring current collector around the circumference of the cell. The active area of the Nafion 117 PEM was 1.2 cm². The enclosed cathode chamber had a total internal volume of 3 ml and during operation the ~1.5 ml of gas phase above the liquid phase was swept with a continuous flow (20 ml/min) of inert carrier gas. The composition of the exit gas, including any gases emitted within the cathode chamber, was analyzed continuously by mass spectrometry. The cathode electrode was constructed from reticulated vitreous carbon foam (ERG Materials and Aerospace Corp.) in the form of a cylinder, 1.2 cm diameter, 1 cm tall, placed in contact with the PEM, filling approximately half of the chamber, and connected electrically to the outside via a titanium wire. The cathode chamber was filled with 1.5 ml concentrated cell suspension, which settled into and filled the foam electrode. The carbon foam provided a high surface area for close contact between the cathode and the microorganisms. Occasionally, gas was released from bubbles formed in the solution by the addition of 5-10 microliters of antifoam agent.

[0192] Preparation of the cell suspension. Initial culture growth. Cells were grown in a continuously stirred tank fermenter, BioFlo 110, with a total internal volume of 1.3L and a typical liquid volume of 0.6L. An initial inoculum of the autotrophic hydrogenotrophic thermophilic methanogen, *Methanothermobacter thermautotrophicus*, DSMZ 3590, was grown at 60°C as a batch culture in a medium containing the following components: Na₃nitrilotriacetate, 0.81 mM; nitrilotriacetic acid, 0.4 mM; NiCl₂·6H₂O, 0.005 mM; CoCl₂·6H₂O, 0.0025 mM; Na₂MoO₄·2H₂O, 0.0025 mM; MgCl₂·6H₂O, 1.0 mM; FeSO₄·7H₂O, 0.2 mM; Na₂SeO₃, 0.001 mM; Na₂WO₄, 0.01 mM; KH₂PO₄, 10 mM; NaCl, 10 mM; L-cysteine, 0.2 mM. This medium was sparged with a 4:1 H₂:CO₂ gas mixture generated with mass flow controllers at a total flow of 250 standard ml/minute. The pH of the medium was initially maintained at 6.85 via a pH stat that used 2M ammonium hydroxide to make adjustments. During the early growth phase of the culture when methane production was limited by cell concentration and increased at an exponential rate, a 0.5M sodium sulfide solution was added as needed to maintain the redox potential below -300 mV. Once the culture was grown and methane production reached a steady-state, the culture maintained the redox potential below -450 mV on its own, using hydrogen as the reducing agent. Sulfide addition was slowed to a minimal rate (<1 ppm of H₂S in the outflow gas, as determined by mass spectrometry).

needed for maintaining steady methane productivity with this strain of methanogen. Under these conditions, steady state methane production corresponds to 96-98% conversion of the input hydrogen.

[0193] Selection of a strain adapted to nearly stationary growth conditions. After steady state conditions had been established, the culture was maintained for several weeks without the addition of fresh medium. Instead, the increased volume of the culture generated by water production during methanogenesis was continually removed. The inorganic nutrients removed along with the removed medium and microorganisms were replaced from a 100x concentrated stock formulated as follows: Na₃ nitrilotriacetate, 81 mM; nitrilotriacetic acid, 40 mM; NiCl₂·6H₂O, 0.5 mM; CoCl₂·6H₂O, 0.25 mM; Na₂MoO₄·2H₂O, 0.25 mM; MgCl₂·6H₂O, 100 mM; FeSO₄·7H₂O, 20 mM; Na₂SeO₃, 0.1 mM; Na₂WO₄, 1.0 mM; KH₂PO₄, 1.0 M; NaCl, 1.0 M; L-cysteine, 20 mM. The goal of maintaining this extended culture under nearly stationary growth conditions was to select for a strain that could perform well and survive under conditions similar to those that are encountered in the electrolysis chamber.

[0194] Performance under electrolysis conditions. The adapted culture, at a cell concentration of 5-7g dry weight/L, was starved for energy by sparging at 250 ml/min with a 4:1 gas mixture of Ar:CO₂ for several hours until neither hydrogen nor methane appeared in the effluent gas stream. The cells in a sample from the culture were then concentrated threefold by centrifugation under anaerobic conditions and resuspended at a final concentration of 15-21 g dry weight/L. One and one half milliliters of this concentrated suspension was placed into the chamber and impregnated into the carbon foam cathode (Fig. 3). The cathode was polarized at a voltage of 3.0 to 4.0 V, relative to the anode, and the gasses emerging from the chamber were monitored in a 20 ml/min flow of He carrier gas. As can be seen in Fig. 15, methane is the sole gas product at voltages less than 4.0V, but a minor proportion of hydrogen gas can also be produced at higher voltages. Other possible electrochemical reaction products, such as carbon monoxide, formic acid or methanol were not detected.

[0195] Various alternative improvements. Many modifications of this setup are anticipated and intended to be within the scope of the claims. Expanded graphite foam or particulate graphite or other high surface to volume electrically conductive materials may be suitable as cathode electrodes. A circulating cathode solution may allow for more rapid and complete gas exchange with the outside of the electrolysis chamber. Alternative temperatures within the scope of claim 1 may allow for more efficient charge transfer across the membrane separating the cathode and anode chamber. Alternative materials, including composite Nafion/PTFE, may be suitable for use as the selectively permeable membrane separating the cathode and anode chambers. Alternative geometries of the chambers may improve the charge and gas transport to and from the microbes. Alternative strains of methanogenic microbes may be more tolerant of the various mechanical strains, electrical demands, and metabolite exposure present in this invention.

TABLE 1

Class	Order	Family	Genus	Species	Taxonomy ID
Archaeoglobi	Archaeoglobales	Archaeoglobaceae	Archaeoglobus	fulgidus	224325
Archaeoglobi	Archaeoglobales	Archaeoglobaceae	Archaeoglobus	infectus	403219
Archaeoglobi	Archaeoglobales	Archaeoglobaceae	Archaeoglobus	lithotrophicus	138903
Archaeoglobi	Archaeoglobales	Archaeoglobaceae	Archaeoglobus	profundus	572546
Archaeoglobi	Archaeoglobales	Archaeoglobaceae	Archaeoglobus	veneficus	58290
Archaeoglobi	Archaeoglobales	Archaeoglobaceae	Archaeoglobus	sp. Arc22	403220
Archaeoglobi	Archaeoglobales	Archaeoglobaceae	Archaeoglobus	sp. Fe70 19	669409
Archaeoglobi	Archaeoglobales	Archaeoglobaceae	Archaeoglobus	sp. Fe70 20	669410
Archaeoglobi	Archaeoglobales	Archaeoglobaceae	Archaeoglobus	sp. N185-A	269231
Archaeoglobi	Archaeoglobales	Archaeoglobaceae	Archaeoglobus	sp. NS-tSRB-2	330389
Archaeoglobi	Archaeoglobales	Archaeoglobaceae	Archaeoglobus	sp. NS70-A	269230
Archaeoglobi	Archaeoglobales	Archaeoglobaceae	Archaeoglobus	sp. PM70-1	387631
Archaeoglobi	Archaeoglobales	Archaeoglobaceae	Archaeoglobus	Unclassified	269247
Archaeoglobi	Archaeoglobales	Archaeoglobaceae	Ferroglobus	placidus	589924
Archaeoglobi	Archaeoglobales	Archaeoglobaceae	Ferroglobus	Unclassified	269249
Archaeoglobi	Archaeoglobales	Archaeoglobaceae	Geoglobus	ahangari	113653
Archaeoglobi	Archaeoglobales	Archaeoglobaceae	Geoglobus	sp. AF1T1440	568410
Archaeoglobi	Archaeoglobales	Archaeoglobaceae	Geoglobus	sp. AF1T2020	568411
Archaeoglobi	Archaeoglobales	Archaeoglobaceae	Geoglobus	sp. AF2T1421	568413
Archaeoglobi	Archaeoglobales	Archaeoglobaceae	Geoglobus	sp. AF2T819	568412
Archaeoglobi	Archaeoglobales	Archaeoglobaceae	Geoglobus	sp. SBH6	565033
Archaeoglobi	Archaeoglobales	Archaeoglobaceae	Geoglobus	sp. SN4	685720
Archaeoglobi	Archaeoglobales	Unclassified	Unclassified	Unclassified	309173
Archaeoglobi	Unclassified	Unclassified	Unclassified	Unclassified	763499
Halobateria	Halobacteriales	Halobacteriaceae	Haladaptatus	cibarius	453847

(continued)

Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Haladaptatus	litoreus	553468
Halobateria	Halobacteriales	Halobacteriaceae	Haladaptatus	paucihalophilus	797209
Halobateria	Halobacteriales	Halobacteriaceae	Halalkalicoccus	jeotgali	413810
Halobateria	Halobacteriales	Halobacteriaceae	Halalkalicoccus	tibetensis	175632
Halobateria	Halobacteriales	Halobacteriaceae	Halalkalicoccus	sp. C15	370968
Halobateria	Halobacteriales	Halobacteriaceae	Halalkalicoccus	Unclassified	663941
Halobateria	Halobacteriales	Halobacteriaceae	Halarchaeum	acidiphilum	489138
Halobateria	Halobacteriales	Halobacteriaceae	Halarchaeum	sp. HY-204-1	744725
Halobateria	Halobacteriales	Halobacteriaceae	Haloalcalophilium	atacamensis	119862
Halobateria	Halobacteriales	Halobacteriaceae	Haloalcalophilium	Unclassified	260475
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	aidinensis	56545
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	algeriensis	337689
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	amyolytica	396317
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	argentinensis	43776
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	californiae	662475
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	hispanica	634497
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	japonica	29282
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	marismortui	272569
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	quadrata	182779
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	siamensis	456446
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sinaiiensis	662476
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	vallismortis	662477
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	Unclassified	44098
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. 113	536043
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. 12B-U	584967

(continued)

Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. 2KYS1	367810
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. 2Sb1	329271
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. 2TK2	251319
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. 2TK3	251320
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. 3TK1	251317
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. 3TL4	367812
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. 3TL6	367809
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. 4TK1	251318
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. 4TK3	251321
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. 5Mm10	329272
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. 9D-U	584968
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. A283	362893
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. A337	362892
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. A43	362894
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. AB19	367757
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. AJ4	222985
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. AJ7	229734
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. Arch325ppt-a	682724
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. ARG-2	69009
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. AS7094	262078
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. aus-5	464028
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. B19-RDX	589455
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. B22-GYDX	589454
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. B44A	370972
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. C205090908-1R	593534

(continued)

Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. CH7	596417
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. CHA1	596418
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. CHB-U	584969
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. D1	242927
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. D21	520558
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. Ez1.2	655453
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. FC130_30	493028
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. FC134_14	493029
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. FC134_15	493030
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. FC137_1	493031
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Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. FC137_11	493033
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(continued)

Class	Order	Family	Genus	Species	Taxonomy ID
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Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. FC168_ 34	493070
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. FC168_ 35	493071

(continued)

Class	Order	Family	Genus	Species	Taxonomy ID
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Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. FC168_4	493076
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. FC168_40	493077
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. FC168_41	493078
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. FC168_5	493079
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. FC168_6	493080
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. FC168_7	493081
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. FC168_8	493082
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. FC168_9	493083
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. GR3	574570
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. GSP101	614216
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. GSP108	614217
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. HST01-2R	575195
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. HST03	575194
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. I.B14	564675
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. I.B17	564677
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. I.B27	564684
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. I.B29	564686
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. I.C3	564689
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. I.C4	564690
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. I.C5	564691
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. I.C6	564692

(continued)

Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. I.C7	564693
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. LCKW-Isolate15A	338959
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. LCKW-Isolate20A	338960
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. LCKW-Isolate20N	338961
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. LK1	796337
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. M4r1	323740
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. MGG2	717750
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. MGG3	717751
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. OHF-1	217171
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. OHF-2	217024
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. Q6	323742
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. RBCA-10^2	584970
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. SP2(1)	402992
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. SP2(2)	402870
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. SP4	402871
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	sp. YW016	340950
Halobateria	Halobacteriales	Halobacteriaceae	Haloarcula	Unclassified	376544
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	jilantaiense	355548
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	noricense	223182
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	piscisalsi	413968
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	salina rum (strain Mex)	33003
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	salina rum (strain Port)	33004
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	salina rum (strain Shark)	33005
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	salinarum R1	478009
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	salinarum sp. NRC-1	64091

(continued)

Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	Unclassified	2243
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. 0Cb11	639868
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. 0Cb21	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. 0Cb22	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. 0Cb23	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. 15C0	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. 15C11	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. 15C21	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. 15C23	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. 15C31	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. 1TK1	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. 1TK2	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. 1TK3	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. 2-24-2	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. 2-24-3	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. 2-24-4	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. 2-24-5	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. 2-24-6	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. 2-24-7	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. 2Ma3	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. 3KYS1	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. 5Mm6	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. 7Sb5	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. 9R	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. AS133	

(continued)

Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. AS28	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. AS7092	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. AUS-1	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. AUS-2	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. BCCS 030	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. BCCS 039	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. BIHGY150/14	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. BIHSTY150/18	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. CH11	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. EL 001	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. EL 002	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. EL 003	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. Ez21	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. EzA	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. FIC145_ 1	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. FIC145_ 2	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. FIC146_ 1	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. FIC146_ 2	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. FIC146_ 3	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. FIC146_ 4	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. GN101	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. GRB	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. HA3	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. halo-3	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. HM01	

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Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. HM02	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. HM11	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. HM13	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. HM3	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. HP-R1	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. HSC3	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. I.B12	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. I.C16	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. I.C17	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. I.C2	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. I.C24	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. I.C26	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. I.C29	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. I.C30	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. I.C31	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. JCM 9447	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. JP-6	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. LCKS000-Isolate10	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. LcKS000-Isolate39	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. LCKS200-Isolate33	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. MO51	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. MVBDU1	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. MVBDU2	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. NCIMB 714	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. NCIMB 718	

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Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. NCIMB 720	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. NCIMB 733	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. NCIMB 734	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. NCIMB 741	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. NCIMB 765	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. P102070208-3O	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. P102070208-3R	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. P92A090908-6O	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. P92A090908-6P	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. SG1	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. SP3(2)	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. TG1	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. IJ-EY1	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. XH3	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	sp. Y12	
Halobateria	Halobacteriales	Halobacteriaceae	Halobacterium	Unclassified	260463
Halobateria	Halobacteriales	Halobacteriaceae	Halobaculum	gomorrense	43928
Halobateria	Halobacteriales	Halobacteriaceae	Halobiforma	haloterrestris	148448
Halobateria	Halobacteriales	Halobacteriaceae	Halobiforma	lacisalsi	358396
Halobateria	Halobacteriales	Halobacteriaceae	Halobiforma	nitratireducens	130048
Halobateria	Halobacteriales	Halobacteriaceae	Halobiforma	Unclassified	417359
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	dombroskii	179637
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	hamelinensis	332168
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	morrhuae	2250
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	qingdaonensis	224402

(continued)

Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	saccharolyticus	62319
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	salifodinae	36738
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	thailandensis	335952
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	Unclassified	29286
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	sp. 001/2	481737
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	sp. 004/1-2	481736
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	sp. BIGigoW09	481735
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	sp. BIHTY10/11	481734
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	sp. CH8B	596420
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	sp. CH8K	596421
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	sp. FC211	493090
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	sp. HA4	723882
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	sp. HP-R5	701664
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	sp. HPA-86	436977
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	sp. HPA-87	436978
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	sp. HSA18	436979
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	sp. HSA19	436980
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	sp. HSA20	436981
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	sp. HSt 2.0	557878
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	sp. HSt 2.2	557879
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	sp. HSt 3.0	557880
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	sp. HSt 3.1	557881
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	sp. HSt 4.0	557882
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	sp. HSt 4.1	557883
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	sp. HSt 5.0	557884

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Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	sp. IS10-2	335951
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	sp. JCM 8979	228414
Halobateria	Halobacteriales	Halobacteriaceae	Halococcus	Unclassified	260465
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	alexandrines	114529
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	antrum	381855
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	berberensis	340952
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	denitrificans	662478
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	elongans	403191
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	gibbonsii	35746
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	larsenii	302484
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	lucentense	523840
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	mediterranei	523841
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	mucosum	662479
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	opilio	381854
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	prahovense	381852
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	rutilus	381853
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sulfurifontis	662480
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	viridis	381851
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	volcanii	309800
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	Unclassified	2253
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. 25H4_1	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. 25H4_2	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. 25H4_3	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. 25H4_4	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. 50C21_1	

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Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. 50C21_2	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. 50C21_3	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. 50C21_4	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. 50C21_5	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. 50C21_6	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. A317	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. A440	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. Aa2.2	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. B-1	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. B-3	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. B-4	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. Bej51	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. BejS3	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. BS1	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. BS2a	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. BS2b	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. BV2	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. CIBAARC2BR	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. CS1-10	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. CS1-3	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. CS1-4	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. CS1-5	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. CS1-7	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. CS1-8	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. CS1-9	

(continued)

Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. CS2-1	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. CS3-01	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. CS3-1	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. CT2-4	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. CT3-3	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. CT3-7	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. CT4-2	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. CT4-3	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. CT4-7	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. D107	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. D1227	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FB247_1	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FB247_10	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FB247_11	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FB247_12	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FB247_13	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FB247_14	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FB247_2	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FB247_3	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FB247_4	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FB247_5	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FB247_6	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FB247_7	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FB247_8	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FB247_9	

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Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FB25_1	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FB25_2	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FB25_3	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FB25_4	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FB25_5	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FB25_6	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FB25_7	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FB25_8	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FB25_9	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FC28_1	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FC28_10	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FC28_11	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FC28_12	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FC28_13	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FC28_14	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FC28_15	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FC28_16	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FC28_17	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FC28_18	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FC28_19	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FC28_2	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FC28_20	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FC28_21	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FC28_3	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FC28_4	

(continued)

Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FC28_5	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FC28_6	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FC28_7	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FC28_8	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FC28_9	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FIB210_1	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FIB210_2	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FIB210_3	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FIB210_4	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FIB210_5	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FIB210_6	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FIB210_7	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FIB210_8	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. FIB210_9	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. GSP103	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. GSP104	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. GSP105	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. GSP106	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. GSP107	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. H4	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. HA1	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. HA2	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. HSC4	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. LSC3	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. LWp2.1	

(continued)

Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. M14	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. M16	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. M5	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. M6	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. M7	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. M8	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. MO20	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. MO25	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. MO52	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. MO55	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. N5	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. PA13	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. PA14	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. PA15	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. PA16	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. PA17	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. SA1	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. SA2	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. SA3	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. SA4	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. SA6	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. SA7	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. Set21	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. SOP	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. SP1(2a)	

(continued)

Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. SP2(3)	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. SP3(1)	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. VKMM004	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. VKMM006	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. VKMM009	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. VKMM01	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. VKMM010	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. VKMM011	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. VKMM015	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. YT216	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. YT226	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. YT228	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. YT236	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. YT247	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	sp. ZJ203	
Halobateria	Halobacteriales	Halobacteriaceae	Haloferax	Unclassified	260473
Halobateria	Halobacteriales	Halobacteriaceae	Halogeometricum	borinquense	469382
Halobateria	Halobacteriales	Halobacteriaceae	Halogeometricum	sp. 50C25	493144
Halobateria	Halobacteriales	Halobacteriaceae	Halogeometricum	sp. 5Sa3	329275
Halobateria	Halobacteriales	Halobacteriaceae	Halogeometricum	sp. KL	627706
Halobateria	Halobacteriales	Halobacteriaceae	Halogeometricum	sp. P29B070208-1P	593539
Halobateria	Halobacteriales	Halobacteriaceae	Halogeometricum	sp. SS1	484017
Halobateria	Halobacteriales	Halobacteriaceae	Halogeometricum	Unclassified	436947
Halobateria	Halobacteriales	Halobacteriaceae	Halogranum	rubrum	553466
Halobateria	Halobacteriales	Halobacteriaceae	Halomicrobium	katesii	437163

(continued)

Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Halomicrobium	mukohataei	485914
Halobateria	Halobacteriales	Halobacteriaceae	Halomicrobium	sp. A191	362891
Halobateria	Halobacteriales	Halobacteriaceae	Halomicrobium	sp. Bet58	643748
Halobateria	Halobacteriales	Halobacteriaceae	Halomicrobium	sp. KM	627707
Halobateria	Halobacteriales	Halobacteriaceae	Halopiger	xanaduensis	797210
Halobateria	Halobacteriales	Halobacteriaceae	Haloplanus	natans	376171
Halobateria	Halobacteriales	Halobacteriaceae	Haloplanus	sp. RO5-8	555874
Halobateria	Halobacteriales	Halobacteriaceae	Haloplanus	Unclassified	682717
Halobateria	Halobacteriales	Halobacteriaceae	Haloquadratum	walsbyi - C23	768065
Halobateria	Halobacteriales	Halobacteriaceae	Haloquadratum	walsbyi - DSM 16790	362976
Halobateria	Halobacteriales	Halobacteriaceae	Haloquadratum	Unclassified	329270
Halobateria	Halobacteriales	Halobacteriaceae	Halorhabdus	tiamatea	430914
Halobateria	Halobacteriales	Halobacteriaceae	Halorhabdus	utahensis	519442
Halobateria	Halobacteriales	Halobacteriaceae	Halorhabdus	Unclassified	643678
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	africanae	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	aidingense	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	alkaliphilum	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	arcis	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	californiense	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	cibarium	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	cibi	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	constantinense	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	coriense	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	distributum	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	ejinorens	

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Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	ezzemoulense	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	halophilum	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	jeotgali	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	lacusprofundi	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	lipolyticum	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	litoreum	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	luteum	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	orientale	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	saccharovorum	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sodomense	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	tebenquichense	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	terrestre	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	tibetense	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	trapanicum	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	vacuolatum	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	xinjiangense	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. 106	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. 11-10^6	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. 11GM-10^3	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. 12-10^3	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. 2TL9	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. 5TL6	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. 9B-U	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. A29	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. A33	

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Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. A407	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. A87B	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. AC 1	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. Arch265ppt-f	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. Arch270ppt-f	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. Arch325ppt-b	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. AS2-1	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. AS2-11	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. AS2-14	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. AS2-17	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. AS2-2	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. AS2-3	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. AS2-5	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. AS2-6	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. AS2-7	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. B10-MWDX	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. B12-RDX	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. B13-MW	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. B20-RDX	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. B23	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. B36	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. B43	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. B6	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. B6-RDX	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. Beja5	

(continued)

Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. Bet217	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. Bet25	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. Bet512	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. BG-1	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. Bitterns-10^3	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. C35	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. CGSA-14	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. CGSA-42	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. CH2	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. CH3	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. CHA-MPN-10^6	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. CHC	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. CHC-U	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. Crystal-Bi-White-U	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. Crystal-Bii-Red-U	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. CS1-2	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. CS4-4	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. CT4-02	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. CY	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. D1A	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. D24	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. DS10	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. DV427	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. DW6	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. E4	

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Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. EN-2	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. ETD6	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. Ez228	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. Ez24	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. Ez26	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. Ez5-1	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. Ez5-2	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. Ez522	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. Ez526	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. Ez59	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. Ez5RB	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. Eza1	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. Eza4	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. EzB1	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. EzS2	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. EzS6	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. F100	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. F23A	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. F42A	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. FIC145	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. FIC234	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. GS1	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. GSL5.48	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. GSP100	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. HALO-G*	

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Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. HBCC-2	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. HEN2-25	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. HEN2-39	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. IB11	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. IB15	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. I.B18	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. I.B19	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. I.B2	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. I.B20	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. I.B21	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. I.B23	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. I.B26	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. I.B28	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. I.B3	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. I.B30	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. I.B4	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. I.B5	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. I.B6	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. I.B8	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. I.B9	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. I.C11	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. I.C12	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. I.C28	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. I.C8	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. I.C9	

(continued)

Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. IMCC2547A	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. IMCC2607	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. IMCC8195	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. L56	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. MG215	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. MG23	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. MG25	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. MG525	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. MG526	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. PV6	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. RBC-10^4	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. RBCA-10^3	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. RBCB-10^2	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. RBCB-10^3	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. s1-1	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. SC1.2	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. SH4	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. Slt1	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. SYM	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. T1/2S95	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP001	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP003	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP004	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP008	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP009	

(continued)

Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP015	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP017	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP018	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP019	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP020	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP023	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP024	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP025	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP026	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP028	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP029	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP033	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP034	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP036	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP037	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP041	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP042	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP044	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP045	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP046	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP048	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP050	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP051	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP053	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP054	

(continued)

Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP055	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP056	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP057	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP058	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP059	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP060	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP062	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP063	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP071	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP074	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP081	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP082	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP084	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP085	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP086	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP094	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP099	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP101	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP103	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP105	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP109	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP115	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP116	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP117	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP118	

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Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP121	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP124	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP125	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP126	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP132	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP133	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP135	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP143	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP145	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP146	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP148	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP149	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP150	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP151	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP152	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP153	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP154	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP158	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP159	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP160	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP162	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP163	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP165	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP167	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP168	

(continued)

Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP169	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP172	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP173	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP175	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP176	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP177	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP178	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP179	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP181	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP182	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP183	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP188	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP189	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP192	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP196	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP197	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP198	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP201	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP202	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP203	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP205	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP207	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP208	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP209	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP210	

(continued)

Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP212	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP214	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP215	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP217	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP218	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP219	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP220	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP222	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP224	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP225	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP226	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP227	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP228	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP229	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP230	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP231	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP233	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP235	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP240	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP244	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP245	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP246	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP247	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP249	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP250	

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Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP252	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP254	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP260	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP261	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP263	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP265	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP267	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP269	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP271	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP272	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP273	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP277	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP300	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP302	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP303	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP306	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP309	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP312	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP313	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP315	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP317	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP318	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP319	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP320	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP329	

(continued)

Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. TP341	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. VKMM017	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. VKMM019	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. VKMM033	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. YT245	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. YW059	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. YYJ	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	sp. YYJ21	
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	archaeon DEEP-1	97928
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	archaeon ORGANIC1_A	98847
Halobateria	Halobacteriales	Halobacteriaceae	Halorubrum	Unclassified	399555
Halobateria	Halobacteriales	Halobacteriaceae	Halosarcina	pallida	411361
Halobateria	Halobacteriales	Halobacteriaceae	Halosarcina	sp. RO1-4	553469
Halobateria	Halobacteriales	Halobacteriaceae	Halosarcina	sp. RO1-64	671107
Halobateria	Halobacteriales	Halobacteriaceae	Halosimplex	carlsbadense	797114
Halobateria	Halobacteriales	Halobacteriaceae	Halosimplex	Unclassified	260471
Halobateria	Halobacteriales	Halobacteriaceae	Halostagnicola	larsenii	353800
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	daqingensis	588898
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	hispanica	392421
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	jeotgali	413811
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	limicola	370323
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	longa	370324
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	saccharevitans	301967
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	salina	504937
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	thermotolerans	121872

(continued)

Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	turkmenica	543526
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	turpansis	239108
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	sp. A206A	
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	sp. A82	
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	sp. AB30	
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	sp. arg-4	
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	sp. D113	
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	sp. D83A	
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	sp. DV582A-1	
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	sp. DV582B-3	
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	sp. DV582c2	
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	sp. DV582c4	
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	sp. E49	
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	sp. E57B	
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	sp. EzB3	
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	sp. EzSm	
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	sp. FIC147	
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	sp. FIC148 1	
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	sp. FIC148 2	
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	sp. GSL-11	
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	sp. L52	
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	sp. LPNTC	
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	sp. MO19	
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	sp. MO23	
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	sp. MO24	

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Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	sp. XJNU-19	
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	sp. XJNU-45	
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	sp. XJNU-45-4	
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	sp. XJNU-86-2	
Halobateria	Halobacteriales	Halobacteriaceae	Haloterrigena	sp. XJNU-97	
Halobateria	Halobacteriales	Halobacteriaceae	Halovivax	asiaticus	332953
Halobateria	Halobacteriales	Halobacteriaceae	Halovivax	ruber	387341
Halobateria	Halobacteriales	Halobacteriaceae	Halovivax	sp. A21	520557
Halobateria	Halobacteriales	Halobacteriaceae	Halovivax	sp. B45	596429
Halobateria	Halobacteriales	Halobacteriaceae	Halovivax	sp. E107	596430
Halobateria	Halobacteriales	Halobacteriaceae	Halovivax	sp. EN-4	388350
Halobateria	Halobacteriales	Halobacteriaceae	Natrialba	aegyptia	129789
Halobateria	Halobacteriales	Halobacteriaceae	Natrialba	aibiensis	248371
Halobateria	Halobacteriales	Halobacteriaceae	Natrialba	asiatica	64602
Halobateria	Halobacteriales	Halobacteriaceae	Natrialba	chahannaoensis	68911
Halobateria	Halobacteriales	Halobacteriaceae	Natrialba	hulunbeirensis	123783
Halobateria	Halobacteriales	Halobacteriaceae	Natrialba	magadii	547559
Halobateria	Halobacteriales	Halobacteriaceae	Natrialba	taiwanensis	160846
Halobateria	Halobacteriales	Halobacteriaceae	Natrialba	wudunaoensis	70318
Halobateria	Halobacteriales	Halobacteriaceae	Natrialba	sp. A137	362883
Halobateria	Halobacteriales	Halobacteriaceae	Natrialba	sp. ATCC 43988	63741
Halobateria	Halobacteriales	Halobacteriaceae	Natrialba	sp. B49	370966
Halobateria	Halobacteriales	Halobacteriaceae	Natrialba	sp. F4A	362882
Halobateria	Halobacteriales	Halobacteriaceae	Natrialba	sp. F5	359307
Halobateria	Halobacteriales	Halobacteriaceae	Natrialba	sp. Tunisia HMg-25	138615

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Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Natrialba	sp. Tunisia HMg-27	138616
Halobateria	Halobacteriales	Halobacteriaceae	Natrialba	Unclassified	549377
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	aidingensis	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	altunense	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	ejinorensense	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	gari	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	pallidum	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	pellirubrum	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	versiforme	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	xinjiang	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	sp. 2TK1	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	sp. 5TK1	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	sp. A85	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	sp. ABDH11	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	sp. ABDH17	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	sp. B19	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	sp. B5-RDX	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	sp. B77A	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	sp. CX2021	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	sp. CY21	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	sp. D74	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	sp. E92B	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	sp. FP1R	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	sp. GSP102	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	sp. GSP109	

(continued)

Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	sp. HA33DX	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	sp. HDS1-1	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	sp. HM06	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	sp. J7	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	sp. LPN89	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	sp. XA3-1	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	sp. XJNU-10	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	sp. XJBU-49	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	sp. XJNU-57	
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	sp. enrichment culture clone ABDH17	630201
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	sp. enrichment culture clone ABDH2	630202
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	sp. enrichment culture clone ABDH34	630203
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	sp. enrichment culture clone ABDH37	630204
Halobateria	Halobacteriales	Halobacteriaceae	Natrinema	Unclassified	261026
Halobateria	Halobacteriales	Halobacteriaceae	Natronobacterium	gregoryi	
Halobateria	Halobacteriales	Halobacteriaceae	Natronobacterium	innermongoliae	
Halobateria	Halobacteriales	Halobacteriaceae	Natronobacterium	sp. 2-24-1	
Halobateria	Halobacteriales	Halobacteriaceae	Natronobacterium	sp. 2-24-8	
Halobateria	Halobacteriales	Halobacteriaceae	Natronobacterium	sp. AS-7091	
Halobateria	Halobacteriales	Halobacteriaceae	Natronobacterium	sp. B-MWDX	
Halobateria	Halobacteriales	Halobacteriaceae	Natronobacterium	sp. SSL-6	
Halobateria	Halobacteriales	Halobacteriaceae	Natronobacterium	sp. SSL6	
Halobateria	Halobacteriales	Halobacteriaceae	Natronobacterium	sp. XJNU-101	
Halobateria	Halobacteriales	Halobacteriaceae	Natronobacterium	sp. XJNU-12	
Halobateria	Halobacteriales	Halobacteriaceae	Natronobacterium	sp. XJNU-13	

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Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Natronobacterium	sp. XJNU-22	
Halobateria	Halobacteriales	Halobacteriaceae	Natronobacterium	sp. XJNU-36	
Halobateria	Halobacteriales	Halobacteriaceae	Natronobacterium	sp. XJNU-39	
Halobateria	Halobacteriales	Halobacteriaceae	Natronobacterium	sp. XJNU-43	
Halobateria	Halobacteriales	Halobacteriaceae	Natronobacterium	sp. XJNU-46	
Halobateria	Halobacteriales	Halobacteriaceae	Natronobacterium	sp. XJNU-62	
Halobateria	Halobacteriales	Halobacteriaceae	Natronobacterium	sp. XJNU-74	
Halobateria	Halobacteriales	Halobacteriaceae	Natronobacterium	sp. XJNU-75	
Halobateria	Halobacteriales	Halobacteriaceae	Natronobacterium	sp. XJNU-77	
Halobateria	Halobacteriales	Halobacteriaceae	Natronobacterium	sp. XJNU-96	
Halobateria	Halobacteriales	Halobacteriaceae	Natronobacterium	sp. XJNU-99	
Halobateria	Halobacteriales	Halobacteriaceae	Natronobacterium	Unclassified	523723
Halobateria	Halobacteriales	Halobacteriaceae	Natronococcus	aibiensis	
Halobateria	Halobacteriales	Halobacteriaceae	Natronococcus	amyolyticus	
Halobateria	Halobacteriales	Halobacteriaceae	Natronococcus	jeotgali	
Halobateria	Halobacteriales	Halobacteriaceae	Natronococcus	occultus	
Halobateria	Halobacteriales	Halobacteriaceae	Natronococcus	occultus SP4	
Halobateria	Halobacteriales	Halobacteriaceae	Natronococcus	xinjiangense	
Halobateria	Halobacteriales	Halobacteriaceae	Natronococcus	yunnanense	
Halobateria	Halobacteriales	Halobacteriaceae	Natronococcus	zabuyensis	
Halobateria	Halobacteriales	Halobacteriaceae	Natronococcus	sp.	
Halobateria	Halobacteriales	Halobacteriaceae	Natronococcus	sp. Ah-36	
Halobateria	Halobacteriales	Halobacteriaceae	Natronococcus	sp. D50	
Halobateria	Halobacteriales	Halobacteriaceae	Natronococcus	sp. D58A	
Halobateria	Halobacteriales	Halobacteriaceae	Natronococcus	sp. E7	

(continued)

Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Natronococcus	sp. F30Al	
Halobateria	Halobacteriales	Halobacteriaceae	Natronococcus	sp. GS3	
Halobateria	Halobacteriales	Halobacteriaceae	Natronococcus	sp. M13	
Halobateria	Halobacteriales	Halobacteriaceae	Natronococcus	sp. Sua-E41	
Halobateria	Halobacteriales	Halobacteriaceae	Natronococcus	sp. Sua-E43	
Halobateria	Halobacteriales	Halobacteriaceae	Natronococcus	sp. TC6	
Halobateria	Halobacteriales	Halobacteriaceae	Natronococcus	sp. XH4	
Halobateria	Halobacteriales	Halobacteriaceae	Natronococcus	sp. XJNU-111	
Halobateria	Halobacteriales	Halobacteriaceae	Natronococcus	sp. enrichment culture clone ABDH12	630205
Halobateria	Halobacteriales	Halobacteriaceae	Natronococcus	Unclassified	236503
Halobateria	Halobacteriales	Halobacteriaceae	Natronolimnobius	baerhuensis	253108
Halobateria	Halobacteriales	Halobacteriaceae	Natronolimnobius	innermongolicus	253107
Halobateria	Halobacteriales	Halobacteriaceae	Natronolimnobius	Unclassified	549379
Halobateria	Halobacteriales	Halobacteriaceae	Natronomonas	pharaonis	348780
Halobateria	Halobacteriales	Halobacteriaceae	Natronomonas	sp. DV462A	585976
Halobateria	Halobacteriales	Halobacteriaceae	Natronomonas	Unclassified	436949
Halobateria	Halobacteriales	Halobacteriaceae	Natronorubum	aibiense	348826
Halobateria	Halobacteriales	Halobacteriaceae	Natronorubum	bangense	61858
Halobateria	Halobacteriales	Halobacteriaceae	Natronorubum	sulfidifaciens	388259
Halobateria	Halobacteriales	Halobacteriaceae	Natronorubum	thiooxidans	308853
Halobateria	Halobacteriales	Halobacteriaceae	Natronorubum	tibetense	63128
Halobateria	Halobacteriales	Halobacteriaceae	Natronorubum	sp. CG-4	640944
Halobateria	Halobacteriales	Halobacteriaceae	Natronorubum	sp. CG-6	640943
Halobateria	Halobacteriales	Halobacteriaceae	Natronorubum	sp. Sua-E01	549372
Halobateria	Halobacteriales	Halobacteriaceae	Natronorubum	sp. Tenzan-10	134815

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Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Natronorubum	sp. Wadi Natrun-19	134814
Halobateria	Halobacteriales	Halobacteriaceae	Natronorubum	sp. XJNU-14	642520
Halobateria	Halobacteriales	Halobacteriaceae	Natronorubum	sp. XJNU-92	642521
Halobateria	Halobacteriales	Halobacteriaceae	Natronorubum	Unclassified	260478
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon 10AH	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon 14AHG	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon 30AH	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon 82M4	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon 86M4	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon 89M4	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon 8AHG	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon 93dLM4	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon 93ILM4	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon 98NT4	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon 9AH	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon B13-RDX	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon CSW1.15.5	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon CSW2.24.4	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon CSW2.25.5	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon CSW2.27.5	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon CSW4.03.5	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon CSW4.05.5	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon CSW4.11.5	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon CSW4.22.4	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon CSW5.28.5	

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Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon CSW6.14.5	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon CSW8.8.11	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon HA15	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon HA25	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon S8a	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon SC4	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon SC7	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon SC8	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon SC9	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon sech10	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon sech14	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon sech4	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon sech6	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon sech7a	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon sech8	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon sech9	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon W1	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	haloarchaeon YNPASCul	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon 309	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon GLYP1	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon GX1	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon GX10	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon GX21	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon GX26	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon GX3	

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Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon GX31	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon GX48	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon GX60	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon GX7	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon GX71	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon GX74	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon HO2-1	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon IMCC2586B	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon IMCC8204	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon KeC-11	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon L1	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon RO1-6	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon RO3-11	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon RO5-14	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon RO5-2	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon Ston11	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon Ston12	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon Ston16	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon Ston2	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon Ston28	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon Ston3	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon Ston5	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon Ston6	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon TBN12	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon TBN19	

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Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon TBN21	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon TBN37	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon TBN4	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon TBN49	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon TBN5	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon TBN51	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon TBN53	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon TNN10	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon TNN18	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon TNN28	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon TNN44	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon TNN50	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	archaeon TNN58	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	halophilic archaeon 194-10	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	halophilic archaeon 1DH38	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	halophilic archaeon 1SC5	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	halophilic archaeon 2DH35	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	halophilic archaeon DH34	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	halophilic archaeon HS47	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	halophilic archaeon MK13-1	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	halophilic archaeon NaxosII	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	halophilic archaeon Palaell	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	halophilic archaeon SC3	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	halophilic archaeon SC6	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	mixed culture haloarchaeon CDI-271	

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Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	mixed culture haloarchaeon CDl-276	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	mixed culture haloarchaeon CDII-272	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	mixed culture haloarchaeon CDIII-273	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	mixed culture haloarchaeon CLI-248	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	mixed culture haloarchaeon CLI-250	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	mixed culture haloarchaeon CLI-257	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	mixed culture haloarchaeon CLI-265	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	mixed culture haloarchaeon YE.LI-230	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	Sambhar Salt Lake archaeon HA1	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	Sambhar Salt Lake archaeon HA6	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	Halobacterium sp. NCIMB 763	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	gen. sp.	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	gen. sp. 524	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	gen. sp. 56	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	gen. sp. 600	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	gen. sp. H1	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	gen. sp. SR1.5	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	gen. sp. T5.7	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	enrichment culture clone SLAb1_archaeon	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	uncultured archaeon DEEP-10	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	uncultured archaeon DEEP-2	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	uncultured archaeon DEEP-5	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	uncultured archaeon DEEP-6	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	uncultured archaeon DEEP-7	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	uncultured archaeon DEEP-8	

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Class	Order	Family	Genus	Species	Taxonomy ID
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	uncultured archaeon DEEP-9	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	uncultured haloarchaeon	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	uncultured haloarchaeon CDI-271	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	uncultured haloarchaeon CDII-272	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	uncultured haloarchaeon CDIII-273	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	uncultured haloarchaeon CLI-248	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	uncultured haloarchaeon CLI-250	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	uncultured haloarchaeon CLI-257	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	uncultured haloarchaeon Envl-181	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	uncultured haloarchaeon Envl-182	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	uncultured haloarchaeon Envl-184	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	uncultured haloarchaeon FLAS10H9	
Halobateria	Halobacteriales	Halobacteriaceae	Unclassified	uncultured haloarchaeon YE.LI-230	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	aarhusense	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	alcaliphilum	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	beijingense	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	bryantii	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	congolense	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	curvum	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	espanolae	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	formicicum	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	ivanovii	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	oryzae	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	palustre	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	subterraneum	

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Class	Order	Family	Genus	Species	Taxonomy ID
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	thermaggregans	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	uliginosum	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp.	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. 0372-D1	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. 169	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. 25	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. 28	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. 8-1	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. AH1	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. BRM9	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. C5/51	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. Ch	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. F	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. GH	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. HD-1	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. IM1	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. M03	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. M2	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. MB4	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. Mg38	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. Mic5c12	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. Mic6c05	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. MK4	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. OM15	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. Ps21	

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Class	Order	Family	Genus	Species	Taxonomy ID
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. SA-12	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. T01	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. T11	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. Tc3	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. TM-8	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. TS2	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. XJ-3a	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	sp. YCM1	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobacterium	Unclassified	176306
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	acididurans	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	arboriphilus	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	curvatus	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	cuticularis	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	filiformis	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	gottschalkii	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	millerae	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	olleyae	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	oralis	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	ruminantium	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	smithii ATCC 35061	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	smithii DSM 11975	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	smithii DSM 2374	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	smithii DSM 2375	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	thaueri	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	woesei	

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Class	Order	Family	Genus	Species	Taxonomy ID
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	wolinii	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	Unclassified	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. 110	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. 1Y	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. 30Y	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. 62	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. 87.7	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. AbM4	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. AK-87	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. CIRG-GMbb01	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. CIRG-GMbb02	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. FM1	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. FMB1	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. FMB2	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. FMB3	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. FMBK1	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. FMBK2	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. FMBK3	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. FMBK4	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. FMBK5	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. FMBK6	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. FMBK7	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. HW23	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. LRsD4	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. Mc30	

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Class	Order	Family	Genus	Species	Taxonomy ID
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. MCTS 1-B	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. MCTS 2-G	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. MD101	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. MD102	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. MD103	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. MD104	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. MD105	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. OCP	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. Rsl3	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. RsW3	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. SM9	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. WBY1	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. XT106	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. XT108	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. XT109	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. YE286	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. YE287	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. YE288	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. YE300	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. YE301	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. YE302	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. YE303	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. YE304	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. YLM1	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. Z4	

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Class	Order	Family	Genus	Species	Taxonomy ID
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. Z6	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. Z8	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	endosymbiont 'TS1' of Trimyema compressum	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	methanogenic endosymbiont of Nyctotherus cordiformis	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	methanogenic endosymbiont of Nyctotherus ovalis	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	methanogenic endosymbiont of Nyctotherus velox	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	methanogenic symbiont RS104	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	methanogenic symbiont RS105	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	methanogenic symbiont RS208	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	methanogenic symbiont RS301	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	methanogenic symbiont RS404	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	methanogenic symbiont RS801	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	methanogenic symbiont RS802	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. HI1	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. HI26	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. HI28	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. HW1	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. HW2	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. HW3	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. LHD12	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. LHD2	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. LHM8	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. LRsD2	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. LRsD3	

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Class	Order	Family	Genus	Species	Taxonomy ID
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. LRsM1	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. R1	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. R2	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. R3	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. R4	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. R5	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. Rsl12	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. Rsl17	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. Rsl4	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. RsW10	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	sp. RsW2	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	uncultured archaeon Ar40	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	uncultured Methanobrevibacter sp.	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	uncultured termite gut bacterium Cd30	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	unidentified methanogen ARC1	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	unidentified methanogen ARC12	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	unidentified methanogen ARC13	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	unidentified methanogen ARC15	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	unidentified methanogen ARC19	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	unidentified methanogen ARC20	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	unidentified methanogen ARC23	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	unidentified methanogen ARC24	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	unidentified methanogen ARC25	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	unidentified methanogen ARC26	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	unidentified methanogen ARC27	

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Class	Order	Family	Genus	Species	Taxonomy ID
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	unidentified methanogen ARC28	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	unidentified methanogen ARC32	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	unidentified methanogen ARC33	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	unidentified methanogen ARC40	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	unidentified methanogen ARC41	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	unidentified methanogen ARC44	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	unidentified methanogen ARC50	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	unidentified methanogen ARC51	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	unidentified methanogen ARC52	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	unidentified methanogen ARC53	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	unidentified methanogen ARC61	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	unidentified methanogen ARC65	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanobrevibacter	unidentified methanogen ARC66	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanosphaera	Stadtmanae	339860
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanosphaera	sp. R6	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanosphaera	Uncultured Methanosphaera sp.	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanosphaera	unidentified methanogen ARC14	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanosphaera	unidentified methanogen ARC17	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanosphaera	unidentified methanogen ARC18	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanosphaera	unidentified methanogen ARC21	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanosphaera	unidentified methanogen ARC29	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanosphaera	unidentified methanogen ARC30	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanosphaera	unidentified methanogen ARC39	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanosphaera	unidentified methanogen ARC43	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanosphaera	unidentified methanogen ARC49	

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Class	Order	Family	Genus	Species	Taxonomy ID
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanosphaera	unidentified methanogen ARC62	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanosphaera	Unidentified methanogen ARC8	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanothermobacter	defluvii	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanothermobacter	marburgensis	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanothermobacter	thermautotrophicus str. Delta H	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanothermobacter	thermautotrophicus str. Winter	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanothermobacter	thermoflexus	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanothermobacter	thermophilus	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanothermobacter	wolfeii	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanothermobacter	sp. RY3	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanothermobacter	sp. THUT3	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanothermobacter	sp. enrichment clone M2	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanothermobacter	sp. enrichment clone PY1	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanothermobacter	sp. enrichment clone PY2	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanothermobacter	sp. enrichment clone SA11	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanothermobacter	sp. enrichment clone SA2	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	archaeon A2.95.53	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	archaeon A8.96.15	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	archaeon A9.96.64	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	archaeon 12aF	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	archaeon 14aZ	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	archaeon 15aZ	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	archaeon 1aR	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	archaeon 1aZ	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	archaeon 25aG	

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Class	Order	Family	Genus	Species	Taxonomy ID
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	archaeon 26aM	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	archaeon 2aG	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	archaeon 36aR	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	archaeon 37aM	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	archaeon 3aG	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	archaeon 40aM	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	archaeon 55aZ	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	archaeon 58aZ	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	archaeon 77aZ	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	archaeon RMA5	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	methanogen 5c	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	methanogen MEm1 associated with Eudiplodinium maggii	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	methanogen MEm2 associated with Eudiplodinium maggii	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	methanogen MEm3 associated with Eudiplodinium maggii	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	methanogen Mlp1 associated with Isotricha prostoma	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	methanogen Mlp2 associated with Isotricha prostoma	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	methanogen MPm1 associated with Polyplastron multivesiculatum	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	methanogen MPm2 associated with Polyplastron multivesiculatum	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	methanogen MPm3 associated with Polyplastron multivesiculatum	

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Class	Order	Family	Genus	Species	Taxonomy ID
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	Methanobacteriaceae archaeon enrichment clone M13	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	Methanobacteriaceae archaeon enrichment culture clone MBT-13	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured Methanobacteriaceae archaeon	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen MRE08	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen RS-MCR07	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen RS-MCR09	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen RS-MCR11	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen RS-MCR12	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen RS-MCR16	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen RS-MCR18	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen RS-MCR21	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen RS-MCR23	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen RS-MCR26	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen RS-MCR27	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen RS-MCR29	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen RS-MCR37	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen RS-MCR44	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen RS-MCR45	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen RS-ME01	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen RS-ME05	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen RS-ME07	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen RS-ME09	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen RS-ME10	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen RS-ME15	

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Class	Order	Family	Genus	Species	Taxonomy ID
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen RS-ME29	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen RS-ME31	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen RS-ME36	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen RS-ME38	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen RS-ME44	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen RS-ME45	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen RS-ME47	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured methanogen RS-ME50	
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanothermus	fervidus	523846
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Methanothermus	sociabilis	2181
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	enrichment culture E21A2	114581
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	archaeon enrichment clone M65	388592
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	uncultured Methanobacteriales archaeon	194842
Methanobacteria	Methanobacteriales	Methanobacteriaceae	Unclassified	Unidentified Methanobacteriales	58668
Methanococci	Methanococcales	Methanocaldococcaceae	Methanocaldococcus	fervens	573064
Methanococci	Methanococcales	Methanocaldococcaceae	Methanocaldococcus	indicus	213231
Methanococci	Methanococcales	Methanocaldococcaceae	Methanocaldococcus	infernus	573063
Methanococci	Methanococcales	Methanocaldococcaceae	Methanocaldococcus	jannaschii	243232
Methanococci	Methanococcales	Methanocaldococcaceae	Methanocaldococcus	vulcanius	579137
Methanococci	Methanococcales	Methanocaldococcaceae	Methanocaldococcus	sp. 70-8-3	345590
Methanococci	Methanococcales	Methanocaldococcaceae	Methanocaldococcus	sp. E1885-M	269226
Methanococci	Methanococcales	Methanocaldococcaceae	Methanocaldococcus	sp. FS406-22	644281
Methanococci	Methanococcales	Methanocaldococcaceae	Methanocaldococcus	sp. KIN24-T80	667126
Methanococci	Methanococcales	Methanocaldococcaceae	Methanocaldococcus	sp. Mc-1-85	213203
Methanococci	Methanococcales	Methanocaldococcaceae	Methanocaldococcus	sp. Mc-2-70	213204

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Class	Order	Family	Genus	Species	Taxonomy ID
Methanococci	Methanococcales	Methanocaldococcaceae	Methanocaldococcus	sp. Mc-2-85	213203
Methanococci	Methanococcales	Methanocaldococcaceae	Methanocaldococcus	sp. Mc-365-70	213206
Methanococci	Methanococcales	Methanocaldococcaceae	Methanocaldococcus	sp. Mc-365-85	213207
Methanococci	Methanococcales	Methanocaldococcaceae	Methanocaldococcus	sp. Mc-l-85	213208
Methanococci	Methanococcales	Methanocaldococcaceae	Methanocaldococcus	sp. Mc-S-85	213209
Methanococci	Methanococcales	Methanocaldococcaceae	Methanocaldococcus	Unclassified	328406
Methanococci	Methanococcales	Methanocaldococcaceae	Methanotorriss	formicicus	213185
Methanococci	Methanococcales	Methanocaldococcaceae	Methanotorriss	igneus	2189
Methanococci	Methanococcales	Methanocaldococcaceae	Methanotorriss	sp. Mc-l-70	213186
Methanococci	Methanococcales	Methanocaldococcaceae	Methanotorriss	sp. Mc-S-70	213187
Methanococci	Methanococcales	Methanocaldococcaceae	Methanotorriss	Unclassified	549381
Methanococci	Methanococcales	Methanococcaceae	Methanococcus	aeolicus	
Methanococci	Methanococcales	Methanococcaceae	Methanococcus	maripaludis	
Methanococci	Methanococcales	Methanococcaceae	Methanococcus	vannielli	
Methanococci	Methanococcales	Methanococcaceae	Methanococcus	voltae	
Methanococci	Methanococcales	Methanococcaceae	Methanococcus	sp. Mc55_ 19	
Methanococci	Methanococcales	Methanococcaceae	Methanococcus	sp. Mc55_ 2	
Methanococci	Methanococcales	Methanococcaceae	Methanococcus	sp. Mc55_ 20	
Methanococci	Methanococcales	Methanococcaceae	Methanococcus	sp. Mc70_ 1	
Methanococci	Methanococcales	Methanococcaceae	Methanococcus	sp. Mc70_ 2	
Methanococci	Methanococcales	Methanococcaceae	Methanococcus	sp. Mc85_ 2	
Methanococci	Methanococcales	Methanococcaceae	Methanococcus	sp. Ms33_ 19	
Methanococci	Methanococcales	Methanococcaceae	Methanococcus	sp. Ms33_ 20	
Methanococci	Methanococcales	Methanococcaceae	Methanococcus	sp. Ms55_ 19	
Methanococci	Methanococcales	Methanococcaceae	Methanococcus	sp. Ms55_ 20	

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Class	Order	Family	Genus	Species	Taxonomy ID
Methanococci	Methanococcales	Methanococcaceae	Methanococcus	sp. P2F9701 a	
Methanococci	Methanococcales	Methanococcaceae	Methanococcus	Unclassified	262498
Methanococci	Methanococcales	Methanococcaceae	Methanothermococcus	okinawensis	
Methanococci	Methanococcales	Methanococcaceae	Methanothermococcus	thermolithotrophicus	
Methanococci	Methanococcales	Methanococcaceae	Methanothermococcus	sp. E1855-M	
Methanococci	Methanococcales	Methanococcaceae	Methanothermococcus	sp. Ep55	
Methanococci	Methanococcales	Methanococcaceae	Methanothermococcus	sp. Ep70	
Methanococci	Methanococcales	Methanococcaceae	Methanothermococcus	sp. Mc-1-55	
Methanococci	Methanococcales	Methanococcaceae	Methanothermococcus	sp. Mc37	
Methanococci	Methanococcales	Methanococcaceae	Methanothermococcus	sp. Mc55	
Methanococci	Methanococcales	Methanococcaceae	Methanothermococcus	sp. Mc70	
Methanococci	Methanococcales	Methanococcaceae	Methanothermococcus	sp. Mc70_19	
Methanococci	Methanococcales	Methanococcaceae	Methanothermococcus	sp. Pal55-Mc	
Methanococci	Methanococcales	Methanococcaceae	Methanothermococcus	sp. enrichment clone M11	388596
Methanococci	Methanococcales	Methanococcaceae	Methanothermococcus	sp. enrichment clone M37	388597
Methanococci	Methanococcales	Methanococcaceae	Methanothermococcus	Unclassified	269251
Methanococci	Methanococcales	Unclassified	Unclassified	archaeal str. vp183	114585
Methanococci	Methanococcales	Unclassified	Unclassified	archaeal str. vp21	114587
Methanococci	Methanococcales	Unclassified	Unclassified	hyperthermophilic methanogen FS406-22	412882
Methanococci	Methanococcales	Unclassified	Unclassified	Unclassified	345627
Methanomicrobia	Methanocellales	Methanocellaceae	Methanocella	paludicola	304371
Methanomicrobia	Methanomicrobiales	Methanocorpusculaceae	Methanocorpusculum	aggregans	176294
Methanomicrobia	Methanomicrobiales	Methanocorpusculaceae	Methanocorpusculum	bavaricum	
Methanomicrobia	Methanomicrobiales	Methanocorpusculaceae	Methanocorpusculum	labreanum	
Methanomicrobia	Methanomicrobiales	Methanocorpusculaceae	Methanocorpusculum	parvum	

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Class	Order	Family	Genus	Species	Taxonomy ID
Methanomicrobia	Methanomicrobiales	Methanocorpusculaceae	Methanocorpusculum	sinense	
Methanomicrobia	Methanomicrobiales	Methanocorpusculaceae	Methanocorpusculum	sp. MSP	
Methanomicrobia	Methanomicrobiales	Methanocorpusculaceae	Methanocorpusculum	sp. T07	
Methanomicrobia	Methanomicrobiales	Methanocorpusculaceae	Methanocorpusculum	sp. T08	
Methanomicrobia	Methanomicrobiales	Methanocorpusculaceae	Methanocorpusculum	Metopus contortus archaeal symbiont	
Methanomicrobia	Methanomicrobiales	Methanocorpusculaceae	Methanocorpusculum	Metopus palaeformis endosymbiont	
Methanomicrobia	Methanomicrobiales	Methanocorpusculaceae	Methanocorpusculum	Trimyema sp. archaeal symbiont	
Methanomicrobia	Methanomicrobiales	Methanocorpusculaceae	Methanocorpusculum	Unclassified	176309
Methanomicrobia	Methanomicrobiales	Methanocorpusculaceae	Methanocorpusculum	uncultured archaeon Ar37	97121
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	bourgensis	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	chikugoensis	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	marisnigri	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	marisnigri JR1	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	palmoiei	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	receptaculi	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	submarinus	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	thermophilus	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	Unclassified	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	sp. 10	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	sp. 20	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	sp. 22	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	sp. BA1	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	sp. dm2	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	sp. HC	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	sp. HC-1	

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Class	Order	Family	Genus	Species	Taxonomy ID
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	sp. IIE1	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	sp. LH	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	sp. LH2	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	sp. M06	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	sp. M07	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	sp. M11	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	sp. MAB1	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	sp. MAB2	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	sp. MAB3	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	sp. MQ-4	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	sp. RPS4	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	sp. T02	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	sp. T03	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	sp. T05	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	sp. T10	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	sp. T14	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	sp. enrichment culture clone BAMC-1	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	sp. enrichment culture clone BAMC-2	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoculleus	uncultured sp.	183762
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanofollis	aquaemaris	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanofollis	ethanolicus	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanofollis	formosanus	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanofollis	liminatans	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanofollis	tationis	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanofollis	sp. YCM2	

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Class	Order	Family	Genus	Species	Taxonomy ID
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanofollis	sp. YCM3	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanofollis	sp. YCM4	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanofollis	Unclassified	262500
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanogenium	boonei	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanogenium	cariaci	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanogenium	frigidum	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanogenium	marinum	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanogenium	organophilum	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanogenium	sp. AK-8	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanogenium	archaeon ACE1_A	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanogenium	archaeon SCALE-14	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanogenium	Unclassified	292409
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoplanus	endosymbiosus	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoplanus	limicola	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoplanus	petrolearius	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoplanus	sp. MobH	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanoplanus	Unclassified	404323
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	archaeon 11aR	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	archaeon 22aZ	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	archaeon 29aM	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	archaeon 34aM	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	archaeon 56aR	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	archaeon 66aM	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	archaeon 6aM	

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Class	Order	Family	Genus	Species	Taxonomy ID
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	strain EBac	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	Nasutitermes takasagoensis symbiont MNt1	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	Nasutitermes takasagoensis symbiont MNt2	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	Pericapritermes nitobei symbiont MPn1	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	Plagiopyla nasuta symbiont	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	methanogenic endosymbiont of Brachonella sp.	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	methanogenic endosymbiont of Caenomorpha sp.	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	methanogenic endosymbiont of Caenomorpha sp. 10	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	methanogenic endosymbiont of Caenomorpha sp. 2	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	methanogenic endosymbiont of Caenomorpha-like sp. 1	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	methanogenic endosymbiont of Caenomorpha-like sp. 4	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	methanogenic endosymbiont of Caenomorpha-like sp. 8	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	uncultured archaeon ACE4_A	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	uncultured archaeon Ar27	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	uncultured archaeon Ar32	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	uncultured archaeon BURTON24_A	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	uncultured Methanomicrobiaceae archaeon	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	uncultured sheep rumen methanogen clone 10	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	uncultured sheep rumen methanogen clone 12	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	uncultured sheep rumen methanogen clone 19	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	uncultured sheep rumen methanogen clone 20	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	uncultured sheep rumen methanogen clone 22	

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Class	Order	Family	Genus	Species	Taxonomy ID
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	uncultured sheep rumen methanogen clone 31	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	uncultured sheep rumen methanogen clone 34	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	uncultured sheep rumen methanogen clone 36	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	uncultured sheep rumen methanogen clone 38	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	uncultured sheep rumen methanogen clone 41	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	uncultured sheep rumen methanogen clone 46	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	uncultured sheep rumen methanogen clone 47	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	uncultured sheep rumen methanogen clone 48	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	uncultured sheep rumen	
				methanogen clone 49	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	uncultured sheep rumen methanogen clone 52	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	uncultured sheep rumen methanogen clone 55	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	uncultured sheep rumen methanogen clone 57	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	uncultured sheep rumen methanogen clone 58	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	uncultured sheep rumen methanogen clone 60	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Unclassified	uncultured sheep rumen methanogen clone 9	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanospirillum	hungatei	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanospirillum	Unclassified	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanospirillum	sp. K18-1	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanospirillum	sp. TM20-1	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanospirillum	sp. enrichment culture clone D2CL_Arch_16S_clone2A	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanospirillum	sp. enrichment culture clone D2CL_Arch_16S_clone2B	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanospirillum	sp. enrichment culture clone D2CL_mvrd_Clone1	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanospirillum	Unclassified	262503

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Class	Order	Family	Genus	Species	Taxonomy ID
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanospirillum	Unclassified	346907
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanomicrobium	Methanomicrobium mobile	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanomicrobium	Methanobacterium sp. enrichment culture clone MBT-1	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanomicrobium	Methanobacterium sp. enrichment culture clone MBT-10	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanomicrobium	Methanobacterium sp. enrichment culture clone MBT-12	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanomicrobium	Methanobacterium sp. enrichment culture clone MBT-2	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanomicrobium	Methanobacterium sp. enrichment culture clone MBT-3	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanomicrobium	Methanobacterium sp. enrichment culture clone MBT-5	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanomicrobium	Methanobacterium sp. enrichment culture clone MBT-6	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanomicrobium	Methanobacterium sp. enrichment culture clone MBT-7	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanomicrobium	Methanobacterium sp. enrichment culture clone MBT-8	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanomicrobium	Methanobacterium sp. enrichment culture clone MBT-9	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanomicrobium	Methanomicrobium sp. enrichment culture clone MBT-4	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanomicrobium	uncultured Methanomicrobium sp.	
Methanomicrobia	Methanomicrobiales	Methanomicrobiaceae	Methanolacinia	Methanolacinia paynteri	
Methanopyri	Methanopyrales	Methanopyraceae		uncultured Methanopyrales archaeon	345629
Thermococci	Thermococcales	Thermococcaceae	Palaeococcus	ferrophilus	

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Class	Order	Family	Genus	Species	Taxonomy ID
Thermococci	Thermococcales	Thermococcaceae	Palaeococcus	Helgesonii	
Thermococci	Thermococcales	Thermococcaceae	Palaeococcus	Sp. Ax00-33	
Thermococci	Thermococcales	Thermococcaceae	Pyrococcus	abyssi	
Thermococci	Thermococcales	Thermococcaceae	Pyrococcus	Furiosus	
Thermococci	Thermococcales	Thermococcaceae	Pyrococcus	Glycovorans	
Thermococci	Thermococcales	Thermococcaceae	Pyrococcus	Horikoshii	
Thermococci	Thermococcales	Thermococcaceae	Pyrococcus	Pyrococcus woesei Pyrococcus sp. Pyrococcus sp. 12/1 Pyrococcus sp. 121 Pyrococcus sp. 303 Pyrococcus sp. 304 Pyrococcus sp. 312 Pyrococcus sp. 32-4 Pyrococcus sp. 321 Pyrococcus sp. 322 Pyrococcus sp. 323 Pyrococcus sp. 324 Pyrococcus sp. 95-12-1 Pyrococcus sp. AV5 Pyrococcus sp. Ax99-7 Pyrococcus sp. C2 Pyrococcus sp. CH1 Pyrococcus sp. ES4 Pyrococcus sp. EX2 Pyrococcus sp. Fla95-Pc Pyrococcus sp. GB-3A Pyrococcus sp. GB-D Pyrococcus sp. GBD Pyrococcus sp. Gl-H Pyrococcus sp. Gl-J	

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Class	Order	Family	Genus	Species	Taxonomy ID
				Pyrococcus sp. GIL Pyrococcus sp. HT3 Pyrococcus sp. JT1 Pyrococcus sp. MA2.31 Pyrococcus sp. MA2.32 Pyrococcus sp. MA2.34 Pyrococcus sp. MV1019 Pyrococcus sp. MV4 Pyrococcus sp. MV7 Pyrococcus sp. MZ14 Pyrococcus sp. MZ4 Pyrococcus sp. NA2 Pyrococcus sp. NS102-T Pyrococcus sp. Pikanate 5017 Pyrococcus sp. ST700 Pyrococcus sp. Tc-2-70 Pyrococcus sp. Tc95-7C-I Pyrococcus sp. TC95-7C-S Pyrococcus sp. Tc95_6 Pyrococcus sp. V211 Pyrococcus sp. V212 Pyrococcus sp. V221 Pyrococcus sp. V222 Pyrococcus sp. V231 Pyrococcus sp. V232 Pyrococcus sp. V61 Pyrococcus sp. V62 Pyrococcus sp. V63 Pyrococcus sp. V72 Pyrococcus sp. V73 Pyrococcus sp. VB112 Pyrococcus sp. VB113 Pyrococcus sp. VB81	

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Class	Order	Family	Genus	Species	Taxonomy ID
				Pyrococcus sp. VB82	
				Pyrococcus sp. VB83	
				Pyrococcus sp. VB85	
				Pyrococcus sp. VB86	
				Pyrococcus sp. VB93	
			Thermococcus	Thermococcus acidaminovorans	
				Thermococcus aegaeus	
				Thermococcus aggregans	
				Thermococcus alcaliphilus	
				Thermococcus atlanticus	
				Thermococcus barophilus	
				Thermococcus barophilus MP	
				Thermococcus barossii	
				Thermococcus celer	
				Thermococcus celericrescens	
				Thermococcus chitonophagus	
				Thermococcus coalescens	
				Thermococcus fomicolans	
				Thermococcus gammatolerans	
				Thermococcus gammatolerans EJ3	
				Thermococcus gorgonarius	
				Thermococcus guaymasensis	
				Thermococcus hydrothermalis	
				Thermococcus kodakarensis	
				Thermococcus kodakarensis KOD1	
				Thermococcus litoralis	
				Thermococcus litoralis DSM 5473	
				Thermococcus marinus	
				Thermococcus mexicalis	
				Thermococcus nautilus	
				Thermococcus onnurineus	
				Thermococcus onnurineus NA1	

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Class	Order	Family	Genus	Species	Taxonomy ID
				Thermococcus pacificus Thermococcus peptonophilus Thermococcus peptonophilus JCM 9653 Thermococcus profundus Thermococcus radiotolerans Thermococcus sibiricus Thermococcus sibiricus MM 739 Thermococcus siculi Thermococcus stetteri Thermococcus thioeducens Thermococcus waimangensis Thermococcus waiotapuensis Thermococcus zilligii Thermococcus sp. Thermococcus sp. 'AEP11 1a' Thermococcus sp. 'Bio pl 0405IT2' Thermococcus sp. 11N.A5 Thermococcus sp. 12-4 Thermococcus sp. 13-2 Thermococcus sp. 13-3 Thermococcus sp. 1519 Thermococcus sp. 21-1 Thermococcus sp. 23-1 Thermococcus sp. 23-2 Thermococcus sp. 26-2 Thermococcus sp. 26-3 Thermococcus sp. 26/2 Thermococcus sp. 28-1 Thermococcus sp. 29-1 Thermococcus sp. 300-Tc Thermococcus sp. 31-1 Thermococcus sp. 31-3 Thermococcus sp. 5-1	

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Class	Order	Family	Genus	Species	Taxonomy ID
				Thermococcus sp. 70-4-2 Thermococcus sp. 83-5-2 Thermococcus sp. 9N2 Thermococcus sp. 9N2.20 Thermococcus sp. 9N2.21 Thermococcus sp. 9N3	
				Thermococcus sp. 9oN-7 Thermococcus sp. A4 Thermococcus sp. AF1T14.13 Thermococcus sp. AF1T1423 Thermococcus sp. AF1T20.11 Thermococcus sp. AF1T6.10 Thermococcus sp. AF1T6.12 Thermococcus sp. AF1T6.63 Thermococcus sp. AF2T511 Thermococcus sp. Ag85-vw Thermococcus sp. AM4 Thermococcus sp. AMT11 Thermococcus sp. Anhete70-l78 Thermococcus sp. Anhete70-SCI Thermococcus sp. Anhete85-l78 Thermococcus sp. Anhete85-SCI Thermococcus sp. AT1273 Thermococcus sp. Ax00-17 Thermococcus sp. Ax00-27 Thermococcus sp. Ax00-39 Thermococcus sp. Ax00-45 Thermococcus sp. Ax01-2 Thermococcus sp. Ax01-3 Thermococcus sp. Ax01-37 Thermococcus sp. Ax01-39 Thermococcus sp. Ax01-61 Thermococcus sp. Ax01-62	

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Class	Order	Family	Genus	Species	Taxonomy ID
				Thermococcus sp. Ax01-65 Thermococcus sp. Ax98-43 Thermococcus sp. Ax98-46 Thermococcus sp. Ax98-48 Thermococcus sp. Ax99-47 Thermococcus sp. Ax99-57 Thermococcus sp. Ax99-67 Thermococcus sp. B1 Thermococcus sp. B1001 Thermococcus sp. B4 Thermococcus sp. BHI60a21 Thermococcus sp. BHI80a28 Thermococcus sp. BHI80a40 Thermococcus sp. CAR-80 Thermococcus sp. CKU-1 Thermococcus sp. CKU-199 Thermococcus sp. CL1 Thermococcus sp. CL2 Thermococcus sp. CMI Thermococcus sp. CNR-5 Thermococcus sp. CX1 Thermococcus sp. CX2 Thermococcus sp. CX3 Thermococcus sp. CX4 Thermococcus sp. CYA Thermococcus sp. Dex80a71 Thermococcus sp. Dex80a75 Thermococcus sp. ES1 Thermococcus sp. Fe85_1_2 Thermococcus sp. GB18 Thermococcus sp. GB20 Thermococcus sp. GE8 Thermococcus sp. Gorda2	

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Class	Order	Family	Genus	Species	Taxonomy ID
				Thermococcus sp. Gorda3	
				Thermococcus sp. Gorda4	
				Thermococcus sp. Gorda5	
				Thermococcus sp. Gorda6	
				Thermococcus sp. GT	
				Thermococcus sp. GU5L5	
				Thermococcus sp. HJ21	
				Thermococcus sp. JDF-3	
				Thermococcus sp. KI	
				Thermococcus sp. KS-1	
				Thermococcus sp. KS-8	
				Thermococcus sp. MA2.27	
				Thermococcus sp. MA2.28	
				Thermococcus sp. MA2.29	
				Thermococcus sp. MA2.33	
				Thermococcus sp. MV1031	
				Thermococcus sp. MV1049	
				Thermococcus sp. MV1083	
				Thermococcus sp. MV1092	
				Thermococcus sp. MV1099	
				Thermococcus sp. MZ1	
				Thermococcus sp. MZ10	
				Thermococcus sp. MZ11	
				Thermococcus sp. MZ12	
				Thermococcus sp. MZ13	
				Thermococcus sp. MZ2	
				Thermococcus sp. MZ3	
				Thermococcus sp. MZ5	
				Thermococcus sp. MZ6	
				Thermococcus sp. MZ8	
				Thermococcus sp. MZ9	
				Thermococcus sp. NS85-T	
				Thermococcus sp. P6	

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Class	Order	Family	Genus	Species	Taxonomy ID
				Thermococcus sp. Pd70 Thermococcus sp. Pd85 Thermococcus sp. Rt3 Thermococcus sp. SB611 Thermococcus sp. SN531 Thermococcus sp. SRB55_1 Thermococcus sp. SRB70_1 Thermococcus sp. SRB70_10 Thermococcus sp. Tc-1-70 Thermococcus sp. Tc-1-85 Thermococcus sp. Tc-1-95 Thermococcus sp. Tc-2-85 Thermococcus sp. Tc-2-95 Thermococcus sp. Tc-365-70 Thermococcus sp. Tc-365-85 Thermococcus sp. Tc-365-95 Thermococcus sp. Tc-4-70 Thermococcus sp. Tc-4-85 Thermococcus sp. Tc-l-70 Thermococcus sp. Tc-l-85 Thermococcus sp. Tc-S-70 Thermococcus sp. Tc-S-85 Thermococcus sp. Tc55_1 Thermococcus sp. Tc55_12 Thermococcus sp. Tc70-4C-l Thermococcus sp. Tc70-4C-S Thermococcus sp. Tc70-7C-l Thermococcus sp. Tc70-7C-S Thermococcus sp. Tc70-CRC-l Thermococcus sp. Tc70-CRC-S Thermococcus sp. Tc70-MC-S Thermococcus sp. Tc70-SC-1 Thermococcus sp. Tc70-SC-S	

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Class	Order	Family	Genus	Species	Taxonomy ID
				Thermococcus sp. Tc70-vw Thermococcus sp. Tc70_1 Thermococcus sp. Tc70_10 Thermococcus sp. Tc70_11 Thermococcus sp. Tc70_12 Thermococcus sp. Tc70_20 Thermococcus sp. Tc70_6 Thermococcus sp. Tc70_9 Thermococcus sp. Tc85-0 age SC Thermococcus sp. Tc85-4C-I Thermococcus sp. Tc85-4C-S Thermococcus sp. Tc85-7C-S Thermococcus sp. Tc85-CRC-I Thermococcus sp. Tc85-CRC-S Thermococcus sp. Tc85-MC-I Thermococcus sp. Tc85-MC-S Thermococcus sp. Tc85-SC-I Thermococcus sp. Tc85-SC-ISCS Thermococcus sp. Tc85-SC-S Thermococcus sp. Tc85_1	
				Thermococcus sp. Tc85_10 Thermococcus sp. Tc85_11 Thermococcus sp. Tc85_12 Thermococcus sp. Tc85_13 Thermococcus sp. Tc85_19 Thermococcus sp. Tc85_2 Thermococcus sp. Tc85_20 Thermococcus sp. Tc85_9 Thermococcus sp. Tc95-CRC-I Thermococcus sp. Tc95-CRC-S Thermococcus sp. Tc95-MC-1 Thermococcus sp. Tc95-MC-S Thermococcus sp. Tc95-SC-S	

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Class	Order	Family	Genus	Species	Taxonomy ID
				Thermococcus sp. TK1	
				Thermococcus sp. TM1	
				Thermococcus sp. TS3	
				Thermococcus sp. vp197	
Thermoplasma	Thermoplasmales			environmental samples	507754
				Thermococcus sp. enrichment clone SA3	
				uncultured Thermococcus sp.	
				aeolicum	
				acidarmanus	
				acidiphilum	
				Cupricumulans	
				Thermophilum	
				Sp. JTC3	
				Sp. clone E8A015	
				Sp. Type II	
				Uncultured Ferroplasma sp.	
				Oshimae	
				torrid us	
				Acidophilum	
				Volcanium	
				Sp. 67.1	
				Sp. P61	
				Sp. S01	
				Sp. S02	
				Sp. Xt101	
				Xt102	
				XT103	

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Class	Order	Family	Genus	Species	Taxonomy ID
		Thermoplasmataceae	Thermoplasmataceae	XT107	
		Thermoplasmataceae	Thermogymnomonas	acidicola	
unclassified	unclassified	unclassified	unclassified	uncultured SA2 group euryarchaeote uncultured SA1 group euryarchaeote	
				uncultured marine euryarchaeote DH148-Y15 uncultured marine euryarchaeote DH148-Y16 uncultured marine euryarchaeote DH148-Y19 uncultured marine euryarchaeote DH148-Y2 uncultured marine euryarchaeote DH148-Y4 uncultured marine euryarchaeote DH148-Z1 uncultured marine group IV euryarchaeote uncultured marine group III euryarchaeote uncultured marine group III euryarchaeote AD1000-40-D7 uncultured marine group III euryarchaeote HF10_21C05 uncultured marine group III euryarchaeote HF130_ 43E12 uncultured marine group III euryarchaeote HF130_95B02 uncultured marine group III euryarchaeote HF200_25B11 uncultured marine group III euryarchaeote HF500_17G02 uncultured marine group III euryarchaeote KM3-28- E8 uncultured marine group III euryarchaeote SAT1000-53-B3 uncultured marine group II euryarchaeote uncultured marine group II euryarchaeote 37F11 uncultured marine group II euryarchaeote AD1000-18-D2	

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Class	Order	Family	Genus	Species	Taxonomy ID
				uncultured marine group II euryarchaeote DeepAnt-15E7	
				uncultured marine group II euryarchaeote DeepAnt-JyKC7	
				uncultured marine group II euryarchaeote EF100_57A08	
				uncultured marine group II euryarchaeote HF10_15F03	
				uncultured marine group II euryarchaeote HF10_15F05	
				uncultured marine group II euryarchaeote HF10_15G04	
				uncultured marine group II euryarchaeote HF10_20F02	
				uncultured marine group II euryarchaeote HF10_24E03	
				uncultured marine group II euryarchaeote HF10_25H10	
				uncultured marine group II euryarchaeote HF10_27F06	
				uncultured marine group II euryarchaeote HF10_28B09	
				uncultured marine group II euryarchaeote HF10_29E05	
				uncultured marine group II euryarchaeote HF10_30E08	
				uncultured marine group II euryarchaeote HF10_30F11	
				uncultured marine group II euryarchaeote HF10_35F06	
				uncultured marine group II euryarchaeote HF10_36B02	
				uncultured marine group II euryarchaeote HF10_39E10	

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Class	Order	Family	Genus	Species	Taxonomy ID
				uncultured marine group II	
				euryarchaeote HF10_43A09 uncultured marine group II euryarchaeote HF10_48G07 uncultured marine group II euryarchaeote HF10_53B05 uncultured marine group II euryarchaeote HF10_61D03 uncultured marine group II euryarchaeote HF10_65D04 uncultured marine group II euryarchaeote HF10_73E12 uncultured marine group II euryarchaeote HF10_8H07 uncultured marine group II euryarchaeote HF10_90C09 uncultured marine group II euryarchaeote HF130_17B12 uncultured marine group II euryarchaeote HF130_17D07 uncultured marine group II euryarchaeote HF130_21B04 uncultured marine group II euryarchaeote HF130_26G06 uncultured marine group II euryarchaeote HF130_27A09 uncultured marine group II euryarchaeote HF130_28F07 uncultured marine group II euryarchaeote HF130_29F10 uncultured marine group II euryarchaeote HF130_30F08 uncultured marine group II euryarchaeote HF130_31B11	

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Class	Order	Family	Genus	Species	Taxonomy ID
				uncultured marine group II euryarchaeote HF130_32D03 uncultured marine group II euryarchaeote HF130_33C02 uncultured marine group II euryarchaeote HF130_34E01 uncultured marine group II euryarchaeote HF130_35A10 uncultured marine group II euryarchaeote HF130_37H07 uncultured marine group II euryarchaeote HF130_40B01 uncultured marine group II euryarchaeote HF130_40B02 uncultured marine group II euryarchaeote HF130_ 40G07 uncultured marine group II euryarchaeote HF130_ 40G09 uncultured marine group II euryarchaeote HF130_44A02 uncultured marine group II euryarchaeote HF130_49F04 uncultured marine group II euryarchaeote HF130_4G08 uncultured marine group II euryarchaeote HF130_56E12 uncultured marine group II euryarchaeote HF130_67F08 uncultured marine group II euryarchaeote HF130_6E07 uncultured marine group II euryarchaeote HF130_71B05 uncultured marine group II euryarchaeote HF130_73G01	

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Class	Order	Family	Genus	Species	Taxonomy ID
				uncultured marine group II euryarchaeote HF130_75B06 uncultured marine group II euryarchaeote HF130_76G06 uncultured marine group II euryarchaeote HF130 83E02	
				uncultured marine group II euryarchaeote HF130_88G10 uncultured marine group II euryarchaeote HF130_90E09 uncultured marine group II euryarchaeote HF130_94A03 uncultured marine group II euryarchaeote HF200_101H01 uncultured marine group II euryarchaeote HF200_102F03 uncultured marine group II euryarchaeote HF200_103E03 uncultured marine group II euryarchaeote HF200_15F06 uncultured marine group II euryarchaeote HF200_25F07 uncultured marine group II euryarchaeote HF200_35B05 uncultured marine group II euryarchaeote HF200_35E02 uncultured marine group II euryarchaeote HF200 _43D02 uncultured marine group II euryarchaeote HF200 _44E05 uncultured marine group II euryarchaeote HF200 _49H12 uncultured marine group II euryarchaeote HF200_50D06	

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Class	Order	Family	Genus	Species	Taxonomy ID
				uncultured marine group II euryarchaeote HF200_63E02 uncultured marine group II euryarchaeote HF200_64G08 uncultured marine group II euryarchaeote HF200_65H08 uncultured marine group II euryarchaeote HF200_66A10 uncultured marine group II euryarchaeote HF200_70E08 uncultured marine group II euryarchaeote HF200_71A04 uncultured marine group II euryarchaeote HF200_72A06 uncultured marine group II euryarchaeote HF200_78D05 uncultured marine group II euryarchaeote HF200_84A01 uncultured marine group II euryarchaeote HF200_89A11 uncultured marine group II euryarchaeote HF200_97B09 uncultured marine group II euryarchaeote HF500_100E05 uncultured marine group II euryarchaeote HF500_11 G07 uncultured marine group II euryarchaeote HF500_22F05 uncultured marine group II euryarchaeote HF500_24F01 uncultured marine group II euryarchaeote HF500_25E08 uncultured marine group II euryarchaeote HF500_26A05	

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Class	Order	Family	Genus	Species	Taxonomy ID
				uncultured marine group II euryarchaeote HF500_30A08 uncultured marine group II euryarchaeote HF500_ 47D04 uncultured marine group II euryarchaeote HF500_56B09 uncultured marine group II euryarchaeote HF500_58A11 uncultured marine group II euryarchaeote HF500_67F10 uncultured marine group II	
				euryarchaeote HF70_105F02 uncultured marine group II euryarchaeote HF70_106D07 uncultured marine group II euryarchaeote HF70_14F12 uncultured marine group II euryarchaeote HF70_25A 12 uncultured marine group II euryarchaeote HF70_39H11 uncultured marine group II euryarchaeote HF70_ 41E01 uncultured marine group II euryarchaeote HF70_48A05 uncultured marine group II euryarchaeote HF70_48G03 uncultured marine group II euryarchaeote HF70_51 B02 uncultured marine group II euryarchaeote HF70_53G11 uncultured marine group II euryarchaeote HF70_59C08 uncultured marine group II euryarchaeote HF70_89B11	

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Class	Order	Family	Genus	Species	Taxonomy ID
				uncultured marine group II euryarchaeote HF70_91 G08 uncultured marine group II euryarchaeote HF70_95E04 uncultured marine group II euryarchaeote HF70_97E04 uncultured marine group II euryarchaeote KM3-130-D10 uncultured marine group II euryarchaeote KM3-136-D10 uncultured marine group II euryarchaeote KM3-72- G3 uncultured marine group II euryarchaeote KM3-85- F5 uncultured marine group II euryarchaeote SAT1000-15-B12 uncultured archaeon ACE-6 uncultured archaeon BURTON-41 uncultured archaeon BURTON-47 uncultured archaeon CLEAR-15 uncultured archaeon CLEAR-24 uncultured archaeon PENDANT-17 uncultured archaeon PENDANT-33 euryarchaeote J3.25-8 euryarchaeote D4.75-18 115532 euryarchaeote D4.75-4 euryarchaeote DJ3.25-13 euryarchaeote J4.75-12 euryarchaeote J4.75-15 euryarchaeote J4.75-24 euryarchaeote SvA99MeOH euryarchaeote SvA99TMA methanogenic archaeon CH1270 methanogenic archaeon F1/B-1	

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Class	Order	Family	Genus	Species	Taxonomy ID
				methanogenic archaeon F1/B-2 methanogenic archaeon F1/B-3 methanogenic archaeon F1/P-1 methanogenic archaeon F1/P-2 methanogenic archaeon F1/P-3 methanogenic archaeon F4/B-1 methanogenic archaeon F4/B-2 methanogenic archaeon F4/B-3 methanogenic archaeon F4/P-1 methanogenic archaeon F4/P-2 methanogenic archaeon F4/P-3 methanogenic archaeon U3/B-1 methanogenic archaeon U3/P-1	
				methanogen sp.	

TABLE 2

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Name of Unclassified Species	Taxonomy ID No.
euryarchaeote enrichment culture clone BAMC-3	679265
euryarchaeote enrichment culture clone MST-5	645575
euryarchaeote enrichment culture clone T-RF243d	670234
euryarchaeote enrichment culture clone T-RF243e	670235
euryarchaeote enrichment culture clone T-RF259	670236
planktonic euryarchaeote	110443
uncultured archaeon BA1a1	92881
uncultured archaeon BA1a2	92882
uncultured archaeon BA1b1	92883
uncultured archaeon BA2e8	92884
uncultured archaeon BA2F4fin	92893
uncultured archaeon BA2H11fin	92894
uncultured archaeon O23F7	114539
uncultured archaeon TA1a4	92885
uncultured archaeon TA1a6	92890
uncultured archaeon TA1a9	92888
uncultured archaeon TA1b12	92886
uncultured archaeon TA1c9	92889
uncultured archaeon TA1e6	92890
uncultured archaeon TA1f2	92891
uncultured archaeon TA2e12	92892
uncultured archaeon WCHA1-57	74278
uncultured archaeon WCHA2-08	74279
uncultured archaeon WCHD3-02	74273
uncultured archaeon WCHD3-07	74274
uncultured archaeon WCHD3-16	74275
uncultured archaeon WCHD3-30	74263
uncultured archaeon WCHD3-33	74276
uncultured archaeon WCHD3-34	74277
uncultured euryarchaeote	114243
uncultured euryarchaeote a118ev	117334
uncultured euryarchaeote a50ev	117335
uncultured euryarchaeote a60ev	117333
uncultured euryarchaeote Alv-FOS1	337892
uncultured euryarchaeote Alv-FOS4	337893
uncultured euryarchaeote Alv-FOS5	337891
uncultured euryarchaeote AM-20A_122	115055

(continued)

	Name of Unclassified Species	Taxonomy ID No.
5	uncultured euryarchaeote AM-20A_123	115056
	uncultured euryarchaeote ARMAN-1	425594
	uncultured euryarchaeote AT-200_29	115057
	uncultured euryarchaeote AT-200_P25	115058
10	uncultured euryarchaeote AT-5_21	115059
	uncultured euryarchaeote AT-5_P24	115060
	uncultured euryarchaeote CA-15_22	115061
15	uncultured euryarchaeote CA-15_23	115062
	uncultured euryarchaeote CA-15_27	115063
	uncultured euryarchaeote CA-15_32	115064
	uncultured euryarchaeote CA-15_P4	115065
20	uncultured euryarchaeote DF-5_21	115066
	uncultured euryarchaeote June4.75-16	134989
	uncultured euryarchaeote ME-450_21	115067
25	uncultured euryarchaeote ME-450_30	115068
	uncultured euryarchaeote ME-450_38	115069
	uncultured euryarchaeote ME-450_P14	115070
	uncultured euryarchaeote ME-450_P9	115071
30	uncultured euryarchaeote pBRKC101	91308
	uncultured euryarchaeote pBRKC112	91309
	uncultured euryarchaeote pBRKC128	91310
35	uncultured euryarchaeote pBRKC134	91312
	uncultured euryarchaeote pBRKC22	91306
	uncultured euryarchaeote pBRKC84	91307
	uncultured euryarchaeote pBRKC91	91311
40	uncultured euryarchaeote SB95-35	115072
	uncultured euryarchaeote SB95-48	115073
	uncultured euryarchaeote SB95-87	115074
45	uncultured euryarchaeote VAL1	85383
	uncultured euryarchaeote VAL112	85386
	uncultured euryarchaeote VAL125	85387
	uncultured euryarchaeote VAL147	85395
50	uncultured euryarchaeote VAL2	85384
	uncultured euryarchaeote VAL28	85394
	uncultured euryarchaeote VAL31-1	85396
55	uncultured euryarchaeote VAL33-1	85397
	uncultured euryarchaeote VAL35-1	85398
	uncultured euryarchaeote VAL40	85392

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	Name of Unclassified Species	Taxonomy ID No.
5	uncultured euryarchaeote VAL47	85388
	uncultured euryarchaeote VAL68	85385
	uncultured euryarchaeote VAL78	85389
	uncultured euryarchaeote VAL84	85390
10	uncultured euryarchaeote VAL9	85393
	uncultured euryarchaeote VAL90	85391
	uncultured Green Bay ferromanganous micronodule archaeon ARB5	140616
15	uncultured Green Bay ferromanganous micronodule archaeon ARC3	140617
	uncultured Green Bay ferromanganous micronodule archaeon ARF3	140614
	uncultured Green Bay ferromanganous micronodule archaeon ARG4	140615
	uncultured haloarchaeon MSP1	75449
20	uncultured haloarchaeon MSP11	75452
	uncultured haloarchaeon MSP12	75453
	uncultured haloarchaeon MSP14	75454
25	uncultured haloarchaeon MSP16	75455
	uncultured haloarchaeon MSP17	75456
	uncultured haloarchaeon MSP22	75457
	uncultured haloarchaeon MSP23	75458
30	uncultured haloarchaeon MSP41	75459
	uncultured haloarchaeon MSP8	75450
	uncultured haloarchaeon MSP9	75451
35	uncultured marine archaeon AEGEAN_50	147164
	uncultured marine archaeon AEGEAN_51	147166
	uncultured marine archaeon AEGEAN_52	147167
	uncultured marine archaeon AEGEAN_53	147168
40	uncultured marine archaeon AEGEAN_54	147174
	uncultured marine archaeon AEGEAN_55	147169
	uncultured marine archaeon AEGEAN_57	147175
45	uncultured marine archaeon AEGEAN_58	147176
	uncultured marine archaeon AEGEAN_59	147177
	uncultured marine archaeon AEGEAN_60	147178
	uncultured marine archaeon AEGEAN_62	147170
50	uncultured marine archaeon AEGEAN_63	147171
	uncultured marine archaeon AEGEAN_64	147172
	uncultured marine archaeon AEGEAN_65	147173
55	uncultured marine archaeon AEGEAN_66	147181
	uncultured marine archaeon AEGEAN_68	147179
	uncultured marine archaeon AEGEAN_71	147180

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	Name of Unclassified Species	Taxonomy ID No.
5	uncultured marine archaeon AEGEAN_73	147182
	uncultured marine archaeon AEGEAN_74	147183
	uncultured marine euryarchaeote	257466
	uncultured marine euryarchaeote dh148-A14	149701
10	uncultured marine euryarchaeote dh148-A18	149702
	uncultured marine euryarchaeote dh148-A7	149700
	uncultured marine euryarchaeote DH148-W1	123945
15	uncultured marine euryarchaeote dh148-W10	149705
	uncultured marine euryarchaeote dh148-W15	149706
	uncultured marine euryarchaeote dh148-W16	149707
	uncultured marine euryarchaeote dh148-W17	149708
20	uncultured marine euryarchaeote dh148-W23	149709
	uncultured marine euryarchaeote DH148-W24	123946
	uncultured marine euryarchaeote dh148-W3	149703
25	uncultured marine euryarchaeote dh148-W9	149704
	uncultured methanogen CIBARC-1	153143
	uncultured methanogen CRARC-3	153144
	uncultured methanogen MRE-MCR1	143132
30	uncultured methanogen MRE-MCR2	143133
	uncultured methanogen MRE-MCR3	143134
	uncultured methanogen MRE-MCR4	143135
35	uncultured methanogen MRE-MCR5	143136
	uncultured methanogen MRE-MCR6	143137
	uncultured methanogen MRE-ME1	143138
	uncultured methanogen MRE-ME3	143139
40	uncultured methanogen MRE-ME4	143140
	uncultured methanogen MRE-ME5	143141
	uncultured methanogen MRE01	143138
45	uncultured methanogen MRE02	143139
	uncultured methanogen MRE03	143144
	uncultured methanogen MRE04	143145
	uncultured methanogen MRE05	143146
50	uncultured methanogen MRE06	143147
	uncultured methanogen MRE07	143148
	uncultured methanogen MRE09	143149
55	uncultured methanogen MRE10	143150
	uncultured methanogen MRE11	143151
	uncultured methanogen MRE12	143152

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Name of Unclassified Species	Taxonomy ID No.
uncultured methanoqen RS-MCR01	143109
uncultured methanoqen RS-MCR04	143110
uncultured methanoqen RS-MCR06	143111
uncultured methanoqen RS-MCR08	143112
uncultured methanoqen RS-MCR10	143113
uncultured methanoqen RS-MCR15	143114
uncultured methanoqen RS-MCR22	143115
uncultured methanoqen RS-MCR25	143116
uncultured methanoqen RS-MCR40	143117
uncultured methanoqen RS-MCR41	143118
uncultured methanoqen RS-MCR43	143119
uncultured methanoqen RS-MCR46	143120
uncultured methanoqen RS-ME11	143121
uncultured methanoqen RS-ME19	143122
uncultured methanoqen RS-ME22	143123
uncultured methanoqen RS-ME24	143124
uncultured methanoqen RS-ME26	143125
uncultured methanoqen RS-ME30	143126
uncultured methanoqen RS-ME32	143127
uncultured methanoqen RS-ME33	143128
uncultured methanoqen RS-ME34	143129
uncultured methanoqen RS-ME39	143130
uncultured methanoqen RS-ME49	143131
uncultured methanoqen VIARC-0	153145
uncultured methanoqen VIARC-4	153146
uncultured methanoqenic archaeon	198240
uncultured methanogenic archaeon 'South African gold mine'	260753
uncultured methanoqenic archaeon RC-I	351160
uncultured methanoqenic symbiont PA101	161327
uncultured methanoqenic symbiont PA102	161319
uncultured methanoqenic symbiont PA103	161318
uncultured methanoqenic symbiont PA104	161306
uncultured methanoqenic symbiont PA105	161336
uncultured methanoqenic symbiont PA112	161305
uncultured methanoqenic symbiont PA114	161320
uncultured methanoqenic symbiont PA119	161303
uncultured methanoqenic symbiont PA123	161302
uncultured methanoqenic symbiont PA124	161329

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	Name of Unclassified Species	Taxonomy ID No.
5	uncultured methanoqenic symbiont PA127	161299
	uncultured methanoqenic symbiont PJ101	161314
	uncultured methanoqenic symbiont PJ102	161335
	uncultured methanoqenic symbiont PJ109	161315
10	uncultured methanoqenic symbiont PJ118	161330
	uncultured methanoqenic symbiont ST102	161337
	uncultured methanoqenic symbiont ST103	161322
15	uncultured methanoqenic symbiont ST104	161300
	uncultured methanoqenic symbiont ST105	161323
	uncultured methanoqenic symbiont ST107	161308
	uncultured methanoqenic symbiont ST109	161317
20	uncultured methanoqenic symbiont ST111	161325
	uncultured methanoqenic symbiont ST113	161328
	uncultured methanoqenic symbiont ST117	161326
25	uncultured methanoqenic symbiont ST126	161324
	uncultured methanoqenic symbiont ST129	161334
	uncultured methanoqenic symbiont ST131	161298
	uncultured methanoqenic symbiont ST140	161313
30	uncultured methanoqenic symbiont ST143	161333
	uncultured methanoqenic symbiont ST144	161307
	uncultured methanoqenic symbiont ST152	161301
35	uncultured methanoqenic symbiont ST153	161311
	uncultured methanoqenic symbiont ST154	161321
	uncultured methanoqenic symbiont ST155	161296
	uncultured methanoqenic symbiont ST157	161297
40	uncultured methanoqenic symbiont ST158	161310
	uncultured methanoqenic symbiont ST159	161316
	uncultured methanoqenic symbiont ST162	161309
45	uncultured methanoqenic symbiont ST164	161304
	uncultured methanoqenic symbiont ST165	161312
	uncultured methanoqenic symbiont ST167	161332
	uncultured methanoqenic symbiont ST168	161331
50	unidentified euryarchaeote	29293
	unidentified methanoqen ARC31	68396
	unidentified methanoqen ARC45	68397
55	unidentified methanoqen ARC46	68398
	unidentified methanoqen ARC63	68399
	unidentified methanoqen ARC64	68400

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Name of Unclassified Species	Taxonomy ID No.
unidentified methanoqen ARC9	68395

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TABLE 3

Name of Unclassified Species	Taxonomy ID
anaerobic methanoqenic archaeon E15-1	93517
anaerobic methanoqenic archaeon E15-10	93526
anaerobic methanoqenic archaeon E15-2	93518
anaerobic methanoqenic archaeon E15-3	93519
anaerobic methanoqenic archaeon E15-4	93520
anaerobic methanoqenic archaeon E15-5	93521
anaerobic methanoqenic archaeon E15-6	93522
anaerobic methanoqenic archaeon E15-7	93523
anaerobic methanoqenic archaeon E15-8	93524
anaerobic methanoqenic archaeon E15-9	93525
anaerobic methanoqenic archaeon E30-1	93527
anaerobic methanoqenic archaeon E30-10	93536
anaerobic methanoqenic archaeon E30-2	93528
anaerobic methanoqenic archaeon E30-3	93529
anaerobic methanoqenic archaeon E30-4	93530
anaerobic methanoqenic archaeon E30-5	93531
anaerobic methanoqenic archaeon E30-6	93532
anaerobic methanoqenic archaeon E30-7	93533
anaerobic methanoqenic archaeon E30-8	93534
anaerobic methanoqenic archaeon E30-9	93535
anaerobic methanoqenic archaeon ET1-1	93507
anaerobic methanoqenic archaeon ET1-10	93516
anaerobic methanoqenic archaeon ET1-2	93508
anaerobic methanoqenic archaeon ET1-3	93509
anaerobic methanoqenic archaeon ET1-4	93510
anaerobic methanoqenic archaeon ET1-5	93511
anaerobic methanoqenic archaeon ET1-6	93512
anaerobic methanoqenic archaeon ET1-7	93513
anaerobic methanoqenic archaeon ET1-8	93514
anaerobic methanoqenic archaeon ET1-9	93515
anaerobic methanoqenic archaeon SN15	548434
anaerobic methanoqenic archaeon SN20	548432
anaerobic methanoqenic archaeon SN22	548433

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Name of Unclassified Species	Taxonomy ID
archaeon #33-9	328513
archaeon 'A215-UMH 22% pond'	199002
archaeon 'A311-UMH 31% pond'	199004
archaeon 'A315-UMH 31% pond'	199005
archaeon 'A319-UMH 31% pond'	199006
archaeon 'A356-UMH 31% pond'	199007
archaeon 'A363-UMH 31% pond'	199008
archaeon 'AN201-UMH 22% pond'	199003
archaeon 26-4a1	210392
archaeon 26-4a6	210393
archaeon 26-5a1	210394
archaeon 26-a101	210395
archaeon 26-a134	210396
archaeon 4R	323739
archaeon A1	631354
archaeon Bitterns-U	584993
archaeon CP.B3	413980
archaeon D3.5-B	115530
archaeon G70	288910
archaeon G76.1	378395
archaeon G76.3	378397
archaeon G76.4	378396
archaeon G80	288911
archaeon GSL1A	378398
archaeon GSL1C	378400
archaeon GSL1D	378399
Name of Unclassified Species	
archaeon HR3812-Enrichment-017	
archaeon HR3812-Enrichment-018	
archaeon HR3812-Enrichment-019	
archaeon HR3812-Enrichment-020	
archaeon HR3812-Enrichment-021	
archaeon HR3812-Enrichment-022	
archaeon K-4a2archaeon K-5a2	
archaeon LL25A1archaeon LL25A10	
archaeon LL25A2archaeon LL25A3	
archaeon LL25A4archaeon LL25A6	
archaeon LL25A7archaeon LL25A8	

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	Name of Unclassified Species	Taxonomy ID
5	archaeon LL37A1archaeon LL37A19	
	archaeon LL37A2archaeon LL37A20	
	archaeon LL37A29	
	archaeon LL37A3	
10	archaeonLL37A33	
	archaeon LL37A35	
	archaeon SL1.19	
15	archaeon SL1.60	
	archaeon SL1.61	
	archaeon SL2.43	
	archaeon SL2.45	
20	archaeon SVAL2.51	
	archaeon SVAL2.52	
	archaeon SVAL2.53	
25	archaeon SVAL2.54	
	archaeon SVAL2.55	
	archaeon SVAL2.56	
	archaeon enrichment clone M21	
30	archaeon enrichment clone M33	
	archaeon enrichment culture clone 10P	
	Aarchaeon enrichment culture clone 1TP	
35	Aarchaeon enrichment culture clone 2TP	
	Aarchaeon enrichment culture clone AOM-Clone-A11	
	archaeon enrichment culture clone AOM-Clone-A2	
	archaeon enrichment culture clone AOM-Clone-B2	
40	archaeon enrichment culture clone AOM-Clone-B6	
	archaeon enrichment culture clone AOM-Clone-C3	
	archaeon enrichment culture clone AOM-Clone-C9	
45	archaeon enrichment culture clone AOM-Clone-D10	
	archaeon enrichment culture clone AOM-Clone-E10	
	archaeon enrichment culture clone AOM-Clone-E7	
	archaeon enrichment culture clone AOM-Clone-E9	
50	archaeon enrichment culture clone AOM-Clone-F5	
	archaeon enrichment culture clone AOM-Clone-F9	
	archaeon enrichment culture clone AOM-Clone-G10	
55	archaeon enrichment culture clone AOM-Clone-H9	
	archaeon enrichment culture clone Arch10	
	archaeon enrichment culture clone ARQ17-JL	

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	Name of Unclassified Species	Taxonomy ID
5	archaeon enrichment culture clone ARQ19-JL	
	archaeon enrichment culture clone ARQ2-JL	
	archaeon enrichment culture clone ARQ9-JL	
10	archaeon enrichment culture clone C1-10C-A	
	archaeon enrichment culture clone C1-11C-A	
	archaeon enrichment culture clone C1-13C-A	
	archaeon enrichment culture clone C1-16C-A	
15	archaeon enrichment culture clone C1-18C-A	
	archaeon enrichment culture clone C1-19C-A	
	archaeon enrichment culture clone C1-1C-A	
	archaeon enrichment culture clone C1-20C-A	
20	archaeon enrichment culture clone C1-24C-A	
	archaeon enrichment culture clone C1-26C-A	
	archaeon enrichment culture clone C1-29C-A	
	archaeon enrichment culture clone C1-2C-A	
25	archaeon enrichment culture clone C1-30C-A	
	archaeon enrichment culture clone C1-31C-A	
	archaeon enrichment culture clone C1-32C-A	
	archaeon enrichment culture clone C1-34C-A	
30	archaeon enrichment culture clone C1-38C-A	
	archaeon enrichment culture clone C1-3C-A	
	archaeon enrichment culture clone C1-42C-A	
	archaeon enrichment culture clone C1-44C-A	
35	archaeon enrichment culture clone C1-46C-A	
	archaeon enrichment culture clone C1-47C-A	
	archaeon enrichment culture clone C1-48C-A	
	archaeon enrichment culture clone C1-4C-A	
40	archaeon enrichment culture clone C1-52C-A	
	archaeon enrichment culture clone C1-5C-A	
	archaeon enrichment culture clone C1-8C-A	
	archaeon enrichment culture clone C3-15C-A	
45	archaeon enrichment culture clone C3-18C-A	
	archaeon enrichment culture clone C3-1C-A	
	archaeon enrichment culture clone C3-20C-A	
	archaeon enrichment culture clone C3-22C-A	
50	archaeon enrichment culture clone C3-26C-A	
	archaeon enrichment culture clone C3-33C-A	
	archaeon enrichment culture clone C3-37C-A	

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	Name of Unclassified Species	Taxonomy ID
5	archaeon enrichment culture clone C3-41C-A	
	archaeon enrichment culture clone C3-42C-A	
	archaeon enrichment culture clone C3-47C-A	
10	archaeon enrichment culture clone C3-54C-A	
	archaeon enrichment culture clone C3-56C-A	
	archaeon enrichment culture clone C3-5C-A	
15	archaeon enrichment culture clone C3-7C-A	
	archaeon enrichment culture clone C4-10C-A	
	archaeon enrichment culture clone C4-11C-A	
20	archaeon enrichment culture clone C4-12C-A	
	archaeon enrichment culture clone C4-14C-A	
	archaeon enrichment culture clone C4-15C-A	
25	archaeon enrichment culture clone C4-16C-A	
	archaeon enrichment culture clone C4-17C-A	
	archaeon enrichment culture clone C4-18C-A	
30	archaeon enrichment culture clone C4-20C-A	
	archaeon enrichment culture clone C4-21C-A	
	archaeon enrichment culture clone C4-22C-A	
35	archaeon enrichment culture clone C4-23C-A	
	archaeon enrichment culture clone C4-24C-A	
	archaeon enrichment culture clone C4-26C-A	
40	archaeon enrichment culture clone C4-27C-A	
	archaeon enrichment culture clone C4-28C-A	
	archaeon enrichment culture clone C4-29C-A	
45	archaeon enrichment culture clone C4-2C-A	
	archaeon enrichment culture clone C4-30C-A	
	archaeon enrichment culture clone C4-32C-A	
50	archaeon enrichment culture clone C4-34C-A	
	archaeon enrichment culture clone C4-35C-A	
	archaeon enrichment culture clone C4-37C-A	
55	archaeon enrichment culture clone C4-38C-A	
	archaeon enrichment culture clone C4-3C-A	
	archaeon enrichment culture clone C4-40C-A	
	archaeon enrichment culture clone C4-41C-A	
	archaeon enrichment culture clone C4-42C-A	
	archaeon enrichment culture clone C4-43C-A	
	archaeon enrichment culture clone C4-45C-A	
	archaeon enrichment culture clone C4-46C-A	

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	Name of Unclassified Species	Taxonomy ID
5	archaeon enrichment culture clone C4-47C-A	
	archaeon enrichment culture clone C4-48C-A	
	archaeon enrichment culture clone C4-49C-A	
10	archaeon enrichment culture clone C4-4C-A	
	archaeon enrichment culture clone C4-50C-A	
	archaeon enrichment culture clone C4-51C-A	
15	archaeon enrichment culture clone C4-52C-A	
	archaeon enrichment culture clone C4-54C-A	
	archaeon enrichment culture clone C4-6C-A	
20	archaeon enrichment culture clone C4-8C-A	
	archaeon enrichment culture clone C4-9C-A	
	archaeon enrichment culture clone Dan60_A10E	
25	archaeon enrichment culture clone Dan60_A11E	
	archaeon enrichment culture clone Dan60_A12E	
	archaeon enrichment culture clone Dan60_A13E	
30	archaeon enrichment culture clone Dan60_A14E	
	archaeon enrichment culture clone Dan60_A15E	
	archaeon enrichment culture clone Dan60_A16E	
35	archaeon enrichment culture clone Dan60_A17E	
	archaeon enrichment culture clone Dan60_A18E	
	archaeon enrichment culture clone Dan60_A19E	
40	archaeon enrichment culture clone Dan60_A1E	
	archaeon enrichment culture clone Dan60_A20E	
	archaeon enrichment culture clone Dan60_A2E	
45	archaeon enrichment culture clone Dan60_A3E	
	archaeon enrichment culture clone Dan60_A4E	
	archaeon enrichment culture clone Dan60_A5E	
50	archaeon enrichment culture clone Dan60_A6E	
	archaeon enrichment culture clone Dan60_A7E	
	archaeon enrichment culture clone Dan60_A8E	
55	archaeon enrichment culture clone Dan60_A9E	
	archaeon enrichment culture clone Dan60S_A10E	
	archaeon enrichment culture clone Dan60S_A11E	
	archaeon enrichment culture clone Dan60S_A12E	
	archaeon enrichment culture clone Dan60S_A13E	
	archaeon enrichment culture clone Dan60S_A14E	
	archaeon enrichment culture clone Dan60S_A15E	
	archaeon enrichment culture clone Dan60S_A16E	

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	Name of Unclassified Species	Taxonomy ID
5	archaeon enrichment culture clone Dan60S_A17E	
	archaeon enrichment culture clone Dan60S_A18E	
	archaeon enrichment culture clone Dan60S_A19E	
	archaeon enrichment culture clone Dan60S_A1E	
10	archaeon enrichment culture clone Dan60S_A20E	
	archaeon enrichment culture clone Dan60S_A2E	
	archaeon enrichment culture clone Dan60S_A3E	
15	archaeon enrichment culture clone Dan60S_A4E	
	archaeon enrichment culture clone Dan60S_A5E	
	archaeon enrichment culture clone Dan60S_A6E	
	archaeon enrichment culture clone Dan60S_A7E	
20	archaeon enrichment culture clone Dan60S_A8E	
	archaeon enrichment culture clone Dan60S_A9E	
	archaeon enrichment culture clone DGGE-1A	
25	archaeon enrichment culture clone DGGE-2A	
	archaeon enrichment culture clone DGGE-4A	
	archaeon enrichment culture clone EA17.1	
	archaeon enrichment culture clone EA29.3	
30	archaeon enrichment culture clone EA29.6	
	archaeon enrichment culture clone EA3.11	
	archaeon enrichment culture clone EA3.3	
35	archaeon enrichment culture clone EA3.5	
	archaeon enrichment culture clone EA8.1	
	archaeon enrichment culture clone EA8.8	
	archaeon enrichment culture clone EA8.9	
40	archaeon enrichment culture clone HS25_1	
	archaeon enrichment culture clone HS7_1	
	archaeon enrichment culture clone LCB_A1C7	
45	archaeon enrichment culture clone LCB_A1C9	
	archaeon enrichment culture clone MBT-11	
	archaeon enrichment culture clone McrA2	
	archaeon enrichment culture clone MST-4	
50	archaeon enrichment culture clone Nye-0_2-enr40	
	archaeon enrichment culture clone PW15.4A	
	archaeon enrichment culture clone PW15.6	
55	archaeon enrichment culture clone PW15.7A	
	archaeon enrichment culture clone PW20.4A	
	archaeon enrichment culture clone PW25.2A	

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	Name of Unclassified Species	Taxonomy ID
5	archaeon enrichment culture clone PW25.9	
	archaeon enrichment culture clone PW30.6A	
	archaeon enrichment culture clone PW32.12A	
	archaeon enrichment culture clone PW32.5A	
10	archaeon enrichment culture clone PW45.1	
	archaeon enrichment culture clone PW45.7A	
	archaeon enrichment culture clone PW45.9A	
15	archaeon enrichment culture clone PW5.2A	
	archaeon enrichment culture clone PW54.3A	
	archaeon enrichment culture clone PW54.4	
	archaeon enrichment culture clone PW68.8A	
20	archaeon enrichment culture clone R3-1a11	
	archaeon enrichment culture clone R3-1a2	
	archaeon enrichment culture clone R3-1a3	
25	archaeon enrichment culture clone R3-1a6	
	archaeon enrichment culture clone R3-1b6	
	archaeon enrichment culture clone R3-1d10	
	archaeon enrichment culture clone R3-1e5	
30	archaeon enrichment culture clone R3-1e8	
	archaeon enrichment culture clone R3-1f5	
	archaeon enrichment culture clone R3-1g4	
35	archaeon enrichment culture clone R3-1h9	
	archaeon enrichment culture clone T-RF321	
	archaeon enrichment culture clone VNC3A001	
	archaeon enrichment culture clone VNC3A005	
40	archaeon enrichment culture clone YE25_1	
	archaeon enrichment culture clone YE7_1	
	archaeon enrichment culture clone YE7_5	
45	archaeon enrichment culture DGGE band 1507aq 1	
	archaeon enrichment culture DGGE band 1507cas 1	
	archaeon enrichment culture DGGE band 1507cas 2	
	archaeon enrichment culture DGGE band 1510b-ker 1	
50	archaeon enrichment culture DGGE band 1510b-ker 2	
	archaeon enrichment culture DGGE band 1521cmc 1	
	archaeon enrichment culture DGGE band 1521cmc 2	
55	archaeon enrichment culture DGGE band 1523rope 1	
	archaeon enrichment culture DGGE band 1523rope 2	
	archaeon enrichment culture DGGE band DS13	

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	Name of Unclassified Species	Taxonomy ID
5	archaeon enrichment culture DGGE band DS18	
	archaeon enrichment culture DGGE band DS19	
	methanogenic archaeon enrichment culture clone 4.17a	Arc Band 1
	methanogenic archaeon enrichment culture clone 4.17b	Arc Band 1
10	methanogenic archaeon enrichment culture clone	BAMC-4
	methanogenic archaeon enrichment culture clone	BAMC-5
	methanogenic archaeon enrichment culture clone	NapK-0_20-enr35
	methanogenic archaeon enrichment culture clone	NapK-0_20-enr36
15	methanogenic archaeon enrichment culture clone	Napk-0_20-enr74
	methanogenic archaeon enrichment culture clone	NapK-80_100-enr37
	toluene-degrading methanogenic consortium archaeon	
20	uncultured ammonia-oxidizing archaeon	
	uncultured archaeal symbiont PA110	
	uncultured archaeal symbiont PA111	
	uncultured archaeal symbiont PA115	
25	uncultured archaeal symbiont PA120	
	uncultured archaeal symbiont PA121	
	uncultured archaeal symbiont PA122	
30	uncultured archaeal symbiont PA201	
	uncultured archaeal symbiont PA202	
	uncultured archaeal symbiont PA203	
	uncultured archaeal symbiont PA204	
35	uncultured archaeal symbiont ST101	
	uncultured archaeal symbiont ST119	
	uncultured archaeal symbiont ST120	
40	uncultured archaeal symbiont ST123	
	uncultured archaeal symbiont ST124	
	uncultured archaeal symbiont ST141	
45	uncultured archaeal symbiont ST150	
	uncultured archaeon	
	uncultured archaeon MedDCM-OCT-S02-C115	
	uncultured archaeon MedDCM-OCT-S04-C14	
50	uncultured archaeon MedDCM-OCT-S04-C140	
	uncultured archaeon MedDCM-OCT-S04-C163	
	uncultured archaeon MedDCM-OCT-S04-C246	
55	uncultured archaeon MedDCM-OCT-S05-C10	
	uncultured archaeon MedDCM-OCT-S05-C205	
	uncultured archaeon MedDCM-OCT-S05-C32	

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	Name of Unclassified Species	Taxonomy ID
5	uncultured archaeon MedDCM-OCT-S05-C418	
	uncultured archaeon MedDCM-OCT-S05-C57	
	uncultured archaeon MedDCM-OCT-S05-C724	
	uncultured archaeon MedDCM-OCT-S06-C18	
10	uncultured archaeon MedDCM-OCT-S08-C16	
	uncultured archaeon MedDCM-OCT-S08-C282	
	uncultured archaeon MedDCM-OCT-S08-C37	
15	uncultured archaeon MedDCM-OCT-S08-C54	
	uncultured archaeon MedDCM-OCT-S08-C82	
	uncultured archaeon MedDCM-OCT-S08-C92	
	uncultured archaeon MedDCM-OCT-S09-C13	
20	uncultured archaeon MedDCM-OCT-S09-C50	
	uncultured archaeon MedDCM-OCT-S11-C441	
	uncultured archaeon MedDCM-OCT-S11-C473	
25	uncultured archaeon 'Antarctica #17'	
	uncultured archaeon 'Norris Geyer Basin #1'	
	uncultured archaeon 'Norris Geyer Basin #13'	
	uncultured archaeon 'Norris Geyer Basin #14'	
30	uncultured archaeon 'Norris Geyer Basin #16'	
	uncultured archaeon 'Norris Geyer Basin #4'	
	uncultured archaeon 'Norris Geyer Basin #6'	
35	uncultured archaeon 'Norris Geyer Basin #8'	
	uncultured archaeon 'Norris Geyer Basin #9'	
	uncultured archaeon 'Obsidian Pool #1'	
	uncultured archaeon 'Obsidian Pool #10'	
40	uncultured archaeon 'Obsidian Pool #3'	
	uncultured archaeon 'Obsidian Pool #4'	
	uncultured archaeon 'Obsidian Pool #6'	
45	uncultured archaeon 'Obsidian Pool #9'	
	uncultured archaeon 'Queen's Laundry #28'	
	uncultured archaeon 101B	
	uncultured archaeon 102A	
50	uncultured archaeon 103D	
	uncultured archaeon 112D	
	uncultured archaeon 113C	
55	uncultured archaeon 130D	
	uncultured archaeon 142C	
	uncultured archaeon 145B	

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	Name of Unclassified Species	Taxonomy ID
5	uncultured archaeon 15A	
	uncultured archaeon 17B	
	uncultured archaeon 19a-1	
	uncultured archaeon 19a-14	
10	uncultured archaeon 19a-18	
	uncultured archaeon 19a-19	
	uncultured archaeon 19a-23	
15	uncultured archaeon 19a-27	
	uncultured archaeon 19a-29	
	uncultured archaeon 19a-4	
	uncultured archaeon 19a-5	
20	uncultured archaeon 19b-1	
	uncultured archaeon 19b-16	
	uncultured archaeon 19b-17	
25	uncultured archaeon 19b-2	
	uncultured archaeon 19b-23	
	uncultured archaeon 19b-24	
	uncultured archaeon 19b-26	
30	uncultured archaeon 19b-30	
	uncultured archaeon 19b-31	
	uncultured archaeon 19b-32	
35	uncultured archaeon 19b-34	
	uncultured archaeon 19b-35	
	uncultured archaeon 19b-37	
	uncultured archaeon 19b-38	
40	uncultured archaeon 19b-39	
	uncultured archaeon 19b-41	
	uncultured archaeon 19b-42	
45	uncultured archaeon 19b-46	
	uncultured archaeon 19b-5	
	uncultured archaeon 19b-52	
	uncultured archaeon 19b-7	
50	uncultured archaeon 19b-8	
	uncultured archaeon 19b-9	
	uncultured archaeon 19c-1	
55	uncultured archaeon 19c-10	
	uncultured archaeon 19c-12	
	uncultured archaeon 19c-17	

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Name of Unclassified Species	Taxonomy ID
uncultured archaeon 19c-18	
uncultured archaeon 19c-27	
uncultured archaeon 19c-31	
uncultured archaeon 19c-33	
uncultured archaeon 19c-35	
uncultured archaeon 19c-36	
uncultured archaeon 19c-45	
uncultured archaeon 19c-49	
uncultured archaeon 19c-5	
uncultured archaeon 19c-50	
uncultured archaeon 19c-51	
uncultured archaeon 19c-52	
uncultured archaeon 19c-53	
uncultured archaeon 19c-54	
uncultured archaeon 1MT315	
uncultured archaeon 1MT325	
uncultured archaeon 20a-1	
uncultured archaeon 20a-10	
uncultured archaeon 20a-12	
uncultured archaeon 20a-15	
uncultured archaeon 20a-17	
uncultured archaeon 20a-2	
uncultured archaeon 20a-25	
uncultured archaeon 20a-28	
uncultured archaeon 20a-3	
uncultured archaeon 20a-6	
uncultured archaeon 20a-7	
uncultured archaeon 20a-9	
uncultured archaeon 20B	
uncultured archaeon 20b-1	
uncultured archaeon 20b-10	
uncultured archaeon 20b-14	
uncultured archaeon 20b-15	
uncultured archaeon 20b-16	
uncultured archaeon 20b-18	
uncultured archaeon 20b-22	
uncultured archaeon 20b-25	
uncultured archaeon 20b-26	

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	Name of Unclassified Species	Taxonomy ID
5	uncultured archaeon 20b-27	
	uncultured archaeon 20b-28	
	uncultured archaeon 20b-30	
	uncultured archaeon 20b-31	
10	uncultured archaeon 20b-37	
	uncultured archaeon 20b-39	
	uncultured archaeon 20b-4	
15	uncultured archaeon 20b-40	
	uncultured archaeon 20b-47	
	uncultured archaeon 20b-53	
	uncultured archaeon 20b-54	
20	uncultured archaeon 20b-7	
	uncultured archaeon 20b-9	
	uncultured archaeon 20c-10	
25	uncultured archaeon 20c-12	
	uncultured archaeon 20c-16	
	uncultured archaeon 20c-17	
	uncultured archaeon 20c-18	
30	uncultured archaeon 20c-19	
	uncultured archaeon 20c-20	
	uncultured archaeon 20c-22	
35	uncultured archaeon 20c-23	
	uncultured archaeon 20c-25	
	uncultured archaeon 20c-29	
40	uncultured archaeon 20c-3	
	uncultured archaeon 20c-37	
	uncultured archaeon 20c-39	
	uncultured archaeon 20c-4	
45	uncultured archaeon 20c-42	
	uncultured archaeon 20c-43	
	uncultured archaeon 20c-47	
50	uncultured archaeon 20c-52	
	uncultured archaeon 20c-54	
	uncultured archaeon 20c-8	
	uncultured archaeon 20D	
55	uncultured archaeon 22C	
	uncultured archaeon 26A	
	uncultured archaeon 27	

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Name of Unclassified Species	Taxonomy ID
uncultured archaeon 27A	
uncultured archaeon 27D	
uncultured archaeon 2C100	
uncultured archaeon 2C129	
uncultured archaeon 2C130	
uncultured archaeon 2C169	
uncultured archaeon 2C174	
uncultured archaeon 2C25	
uncultured archaeon 2C30	
uncultured archaeon 2C300X	
uncultured archaeon 2C46	
uncultured archaeon 2C8	
uncultured archaeon 2C82	
uncultured archaeon 2C83	
uncultured archaeon 2C84	
uncultured archaeon 2C87	
uncultured archaeon 2C9	
uncultured archaeon 2MT1	
uncultured archaeon 2MT103	
uncultured archaeon 2MT120	
uncultured archaeon 2MT16	
uncultured archaeon 2MT196	
uncultured archaeon 2MT198	
uncultured archaeon 2MT22	
uncultured archaeon 2MT310	
uncultured archaeon 2MT320	
uncultured archaeon 2MT53	
uncultured archaeon 2MT7	
uncultured archaeon 2MT8	
uncultured archaeon 2MT98	
uncultured archaeon 60B	
uncultured archaeon 61B	
uncultured archaeon 61D	
uncultured archaeon 63-A1	
uncultured archaeon 63-A10	
uncultured archaeon 63-A11	
uncultured archaeon 63-A12	
uncultured archaeon 63-A14	

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5	Name of Unclassified Species	Taxonomy ID
	uncultured archaeon 63-A15	
	uncultured archaeon 63-A16	
	uncultured archaeon 63-A17	
	uncultured archaeon 63-A18	
10	uncultured archaeon 63-A19	
	uncultured archaeon 63-A20	
	uncultured archaeon 63-A21	
	uncultured archaeon 63-A22	
	uncultured archaeon 63-A23	
15	uncultured archaeon 63-A24	
	uncultured archaeon 63-A3	
	uncultured archaeon 63-A4	
	uncultured archaeon 63-A5	
	uncultured archaeon 63-A6	
20	uncultured archaeon 63-A7	
	uncultured archaeon 63-A8	
	uncultured archaeon 63-A9	
	uncultured archaeon 63D	
	uncultured archaeon 64D	
25	uncultured archaeon 65B	
	uncultured archaeon 65C	
	uncultured archaeon 66D	
	uncultured archaeon 70A	
	uncultured archaeon 71A	
30	uncultured archaeon 71C	
	uncultured archaeon 73A	
	uncultured archaeon 73D	
	uncultured archaeon 76A	
	uncultured archaeon 80B	
35	uncultured archaeon 82D	
	uncultured archaeon 83D	
	uncultured archaeon 84C	
	uncultured archaeon 85A	
	uncultured archaeon 90C	
40	uncultured archaeon 91B	
	uncultured archaeon 93A	
	uncultured archaeon 94B	
	uncultured archaeon 94D	

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	Name of Unclassified Species	Taxonomy ID
5	uncultured archaeon 95A	
	uncultured archaeon A016	
	uncultured archaeon A140	
	uncultured archaeon A145	
10	uncultured archaeon A148	
	uncultured archaeon A151	
	uncultured archaeon A153	
15	uncultured archaeon A154	
	uncultured archaeon A157	
	uncultured archaeon A174	
	uncultured archaeon A175	
20	uncultured archaeon A177	
	uncultured archaeon A178	
	uncultured archaeon ACA1-0cm	
25	uncultured archaeon ACA1-9cm	
	uncultured archaeon ACA10-0cm	
	uncultured archaeon ACA16-9cm	
	uncultured archaeon ACA17-9cm	
30	uncultured archaeon ACA3-0cm	
	uncultured archaeon ACA4-0cm	
	uncultured archaeon AM-1	
35	uncultured archaeon AM-10	
	uncultured archaeon AM-11	
	uncultured archaeon AM-12	
	uncultured archaeon AM-13	
40	uncultured archaeon AM-14	
	uncultured archaeon AM-15	
	uncultured archaeon AM-16	
45	uncultured archaeon AM-17	
	uncultured archaeon AM-18	
	uncultured archaeon AM-19	
	uncultured archaeon AM-2	
50	uncultured archaeon AM-20	
	uncultured archaeon AM-21	
	uncultured archaeon AM-22	
55	uncultured archaeon AM-3	
	uncultured archaeon AM-4	
	uncultured archaeon AM-5	

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	Name of Unclassified Species	Taxonomy ID
5	uncultured archaeon AM-6	
	uncultured archaeon AM-7	
	uncultured archaeon AM-8	
	uncultured archaeon AM-9	
10	uncultured archaeon APA1-0cm	
	uncultured archaeon APA2-17cm	
	uncultured archaeon APA3-0cm	
15	uncultured archaeon APA3-11cm	
	uncultured archaeon APA4-0cm	
	uncultured archaeon APA6-17cm	
	uncultured archaeon APA7-17cm	
20	uncultured archaeon Ar21	
	uncultured archaeon Ar26	
	uncultured archaeon Ar28	
25	uncultured archaeon Arc.1	
	uncultured archaeon Arc.118	
	uncultured archaeon Arc.119	
	uncultured archaeon Arc.148	
30	uncultured archaeon Arc.168	
	uncultured archaeon Arc.171	
	uncultured archaeon Arc.2	
35	uncultured archaeon Arc.201	
	uncultured archaeon Arc.212	
	uncultured archaeon Arc.22	
40	uncultured archaeon Arc.3	
	uncultured archaeon Arc.4	
	uncultured archaeon Arc.43	
	uncultured archaeon Arc.75	
45	uncultured archaeon Arc.9	
	uncultured archaeon Arc.98	
	uncultured archaeon Cas14#1	
	uncultured archaeon Cas14#2	
50	uncultured archaeon Cas14#3	
	uncultured archaeon Cas14#4	
	uncultured archaeon Cas14#5	
55	uncultured archaeon Cas14#6	
	uncultured archaeon Cas18#1	
	uncultured archaeon Cas18#2	

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	Name of Unclassified Species	Taxonomy ID
5	uncultured archaeon Cas18#3	
	uncultured archaeon Cas18#4	
	uncultured archaeon Cas19#1	
	uncultured archaeon Cas19#2	
10	uncultured archaeon Cas19#3	
	uncultured archaeon Cas19#4	
	uncultured archaeon Cas19#5	
15	uncultured archaeon Cas19#6	
	uncultured archaeon Cas20#1	
	uncultured archaeon Cas20#2	
	uncultured archaeon Cas20#3	
20	uncultured archaeon Cas20#4	
	uncultured archaeon Cas20#5	
	uncultured archaeon CR-PA10a	
25	uncultured archaeon CR-PA12a	
	uncultured archaeon CR-PA13a	
	uncultured archaeon CR-PA15a	
	uncultured archaeon CR-PA16a	
30	uncultured archaeon CR-PA1a	
	uncultured archaeon CR-PA2a	
	uncultured archaeon CR-PA4a	
35	uncultured archaeon CR-PA6a	
	uncultured archaeon CR-PA7a	
	uncultured archaeon CR-PA8a	
40	uncultured archaeon CRA12-27cm	
	uncultured archaeon CRA13-11cm	
	uncultured archaeon CRA20-0cm	
	uncultured archaeon CRA36-0cm	
45	uncultured archaeon CRA4-23cm	
	uncultured archaeon CRA7-0cm	
	uncultured archaeon CRA7-11cm	
	uncultured archaeon CRA8-11cm	
50	uncultured archaeon CRA8-23cm	
	uncultured archaeon CRA8-27cm	
	uncultured archaeon CRA9-27cm	
55	uncultured archaeon CRE-FL10a	
	uncultured archaeon CRE-FL11a	
	uncultured archaeon CRE-FL1a	

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	Name of Unclassified Species	Taxonomy ID
5	uncultured archaeon CRE-FL2a	
	uncultured archaeon CRE-FL3a	
	uncultured archaeon CRE-FL4a	
	uncultured archaeon CRE-FL5a	
10	uncultured archaeon CRE-FL6a	
	uncultured archaeon CRE-FL7a	
	uncultured archaeon CRE-FL8a	
15	uncultured archaeon CRE-FL9a	
	uncultured archaeon CRE-PA10a	
	uncultured archaeon CRE-PA11a	
	uncultured archaeon CRE-PA2a	
20	uncultured archaeon CRE-PA3a	
	uncultured archaeon CRE-PA4a	
	uncultured archaeon CRE-PA5a	
25	uncultured archaeon CRE-PA6a	
	uncultured archaeon CRE-PA7a	
	uncultured archaeon CRE-PA8a	
	uncultured archaeon CRE-PA9a	
30	uncultured archaeon CRO-11a	
	uncultured archaeon CRO-12a	
	uncultured archaeon CRO-14a	
35	uncultured archaeon CRO-1a	
	uncultured archaeon CRO-2a	
	uncultured archaeon CRO-3a	
	uncultured archaeon CRO-4a	
40	uncultured archaeon CRO-5a	
	uncultured archaeon CRO-6a	
	uncultured archaeon CRO-7a	
45	uncultured archaeon CRO-8a	
	uncultured archaeon DGGE band PSARC-1	
	uncultured archaeon DGGE band PSARC-2	
	uncultured archaeon E1b	
50	uncultured archaeon ER-E	
	uncultured archaeon ER-H	
	uncultured archaeon GA01	
55	uncultured archaeon GA02	
	uncultured archaeon GA04	
	uncultured archaeon GA10	

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Name of Unclassified Species	Taxonomy ID
uncultured archaeon GA32	
uncultured archaeon GA42	
uncultured archaeon GA54	
uncultured archaeon GA55	
uncultured archaeon GA67	
uncultured archaeon GA77	
uncultured archaeon GZfos10C7	
uncultured archaeon GZfos11A10	
uncultured archaeon GZfos11H11	
uncultured archaeon GZfos12E1	
uncultured archaeon GZfos12E2	
uncultured archaeon GZfos13E1	
uncultured archaeon GZfos14B8	
uncultured archaeon GZfos17A3	
uncultured archaeon GZfos17C7	
uncultured archaeon GZfos17F1	
uncultured archaeon GZfos17G11	
uncultured archaeon GZfos18B6	
uncultured archaeon GZfos18C8	
uncultured archaeon GZfos18F2	
uncultured archaeon GZfos18H11	
uncultured archaeon GZfos19A5	
uncultured archaeon GZfos19C7	
uncultured archaeon GZfos19C8	
uncultured archaeon GZfos1C11	
uncultured archaeon GZfos1D1	
uncultured archaeon GZfos21B5	
uncultured archaeon GZfos22D9	
uncultured archaeon GZfos23H7	
uncultured archaeon GZfos23H9	
uncultured archaeon GZfos24D9	
uncultured archaeon GZfos26B2	
uncultured archaeon GZfos26D6	
uncultured archaeon GZfos26D8	
uncultured archaeon GZfos26E7	
uncultured archaeon GZfos26F9	
uncultured archaeon GZfos26G2	
uncultured archaeon GZfos27A8	

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	Name of Unclassified Species	Taxonomy ID
5	uncultured archaeon GZfos27B6	
	uncultured archaeon GZfos27E6	
	uncultured archaeon GZfos27E7	
	uncultured archaeon GZfos27G5	
10	uncultured archaeon GZfos28B8	
	uncultured archaeon GZfos28G7	
	uncultured archaeon GZfos29E12	
15	uncultured archaeon GZfos30H9	
	uncultured archaeon GZfos31B6	
	uncultured archaeon GZfos32E4	
	uncultured archaeon GZfos32E7	
20	uncultured archaeon GZfos32G12	
	uncultured archaeon GZfos33E1	
	uncultured archaeon GZfos33H6	
25	uncultured archaeon GZfos34A6	
	uncultured archaeon GZfos34G5	
	uncultured archaeon GZfos34H10	
	uncultured archaeon GZfos34H9	
30	uncultured archaeon GZfos35A2	
	uncultured archaeon GZfos35B7	
	uncultured archaeon GZfos35D7	
35	uncultured archaeon GZfos36D8	
	uncultured archaeon GZfos37B2	
	uncultured archaeon GZfos37D1	
	uncultured archaeon GZfos3D4	
40	uncultured archaeon GZfos9C4	
	uncultured archaeon GZfos9D1	
	uncultured archaeon GZfos9D8	
45	uncultured archaeon GZfos9E5	
	uncultured archaeon HA01	
	uncultured archaeon HA03	
	uncultured archaeon HA04	
50	uncultured archaeon HA05	
	uncultured archaeon HA06	
	uncultured archaeon HA08	
55	uncultured archaeon HA09	
	uncultured archaeon HA10	
	uncultured archaeon HA11	

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	Name of Unclassified Species	Taxonomy ID
5	uncultured archaeon HA19	
	uncultured archaeon HA25	
	uncultured archaeon HA48	
	uncultured archaeon HA55	
10	uncultured archaeon KNIA11	
	uncultured archaeon KNIA12	
	uncultured archaeon KNIA13	
15	uncultured archaeon KNIA14	
	uncultured archaeon KNIA15	
	uncultured archaeon n1d	
	uncultured archaeon n41r	
20	uncultured archaeon OS-1	
	uncultured archaeon OS-10	
	uncultured archaeon OS-11	
25	uncultured archaeon OS-12	
	uncultured archaeon OS-13	
	uncultured archaeon OS-14	
	uncultured archaeon OS-15	
30	uncultured archaeon OS-16	
	uncultured archaeon OS-17	
	uncultured archaeon OS-18	
35	uncultured archaeon OS-19	
	uncultured archaeon OS-2	
	uncultured archaeon OS-20	
	uncultured archaeon OS-21	
40	uncultured archaeon OS-22	
	uncultured archaeon OS-23	
	uncultured archaeon OS-24	
45	uncultured archaeon OS-25	
	uncultured archaeon OS-26	
	uncultured archaeon OS-27	
	uncultured archaeon OS-28	
50	uncultured archaeon OS-29	
	uncultured archaeon OS-3	
	uncultured archaeon OS-30	
55	uncultured archaeon OS-31	
	uncultured archaeon OS-32	
	uncultured archaeon OS-33	

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	Name of Unclassified Species	Taxonomy ID
5	uncultured archaeon OS-4	
	uncultured archaeon OS-5	
	uncultured archaeon OS-6	
	uncultured archaeon OS-7	
10	uncultured archaeon OS-8	
	uncultured archaeon OS-9	
	uncultured archaeon pHGPA1	
15	uncultured archaeon pHGPA13	
	uncultured archaeon pPACMA-A	
	uncultured archaeon pPACMA-B	
	uncultured archaeon pPACMA-C	
20	uncultured archaeon pPACMA-E	
	uncultured archaeon pPACMA-F	
	uncultured archaeon pPACMA-G	
25	uncultured archaeon pPACMA-H	
	uncultured archaeon pPACMA-I	
	uncultured archaeon pPACMA-J	
	uncultured archaeon pPACMA-K	
30	uncultured archaeon pPACMA-L	
	uncultured archaeon pPACMA-M	
	uncultured archaeon pPACMA-N	
35	uncultured archaeon pPACMA-P	
	uncultured archaeon pPACMA-Q	
	uncultured archaeon pPACMA-S	
	uncultured archaeon pPACMA-T	
40	uncultured archaeon pPACMA-U	
	uncultured archaeon pPACMA-V	
	uncultured archaeon pPACMA-W	
45	uncultured archaeon pPACMA-X	
	uncultured archaeon pPACMA-Y	
	uncultured archaeon pPCA10.1	
	uncultured archaeon pPCA12.14	
50	uncultured archaeon pPCA12.6	
	uncultured archaeon pPCA13.4	
	uncultured archaeon pPCA13.5	
55	uncultured archaeon pPCA14.16	
	uncultured archaeon pPCA14.17	
	uncultured archaeon pPCA14.18	

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	Name of Unclassified Species	Taxonomy ID
5	uncultured archaeon pPCA14.41	
	uncultured archaeon pPCA15.21	
	uncultured archaeon pPCA17.1	
	uncultured archaeon pPCA19.6	
10	uncultured archaeon pPCA2.4	
	uncultured archaeon pPCA4.21	
	uncultured archaeon pPCA4.4	
15	uncultured archaeon pPCA4.9	
	uncultured archaeon pPCA7.13	
	uncultured archaeon pPCA7.17	
	uncultured archaeon pPCA7.21	
20	uncultured archaeon pPCA7.30	
	uncultured archaeon pPCA7.34	
	uncultured archaeon pPCA7.6	
25	uncultured archaeon pPCA7.8	
	uncultured archaeon pPCA8.3	
	uncultured archaeon RSS50-1	
	uncultured archaeon RSS50-10	
30	uncultured archaeon RSS50-11	
	uncultured archaeon RSS50-2	
	uncultured archaeon RSS50-3	
35	uncultured archaeon RSS50-4	
	uncultured archaeon RSS50-5	
	uncultured archaeon RSS50-6	
	uncultured archaeon RSS50-7	
40	uncultured archaeon RSS50-8	
	uncultured archaeon RSS50-9	
	uncultured archaeon S15-1	
45	uncultured archaeon S15-10	
	uncultured archaeon S15-11	
	uncultured archaeon S15-12	
	uncultured archaeon S15-13	
50	uncultured archaeon S15-14	
	uncultured archaeon S15-15	
	uncultured archaeon S15-16	
55	uncultured archaeon S15-17	
	uncultured archaeon S15-18	
	uncultured archaeon S15-19	

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Name of Unclassified Species	Taxonomy ID
uncultured archaeon S15-2	
uncultured archaeon S15-20	
uncultured archaeon S15-21	
uncultured archaeon S15-22	
uncultured archaeon S15-23	
uncultured archaeon S15-24	
uncultured archaeon S15-25	
uncultured archaeon S15-26	
uncultured archaeon S15-27	
uncultured archaeon S15-28	
uncultured archaeon S15-29	
uncultured archaeon S15-3	
uncultured archaeon S15-30	
uncultured archaeon S15-4	
uncultured archaeon S15-5	
uncultured archaeon S15-6	
uncultured archaeon S15-7	
uncultured archaeon S15-8	
uncultured archaeon S15-9	
uncultured archaeon S30-1	
uncultured archaeon S30-10	
uncultured archaeon S30-11	
uncultured archaeon S30-12	
uncultured archaeon S30-13	
uncultured archaeon S30-14	
uncultured archaeon S30-15	
uncultured archaeon S30-16	
uncultured archaeon S30-17	
uncultured archaeon S30-18	
uncultured archaeon S30-19	
uncultured archaeon S30-2	
uncultured archaeon S30-20	
uncultured archaeon S30-21	
uncultured archaeon S30-22	
uncultured archaeon S30-23	
uncultured archaeon S30-24	
uncultured archaeon S30-25	
uncultured archaeon S30-26	

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Name of Unclassified Species	Taxonomy ID
uncultured archaeon S30-27	
uncultured archaeon S30-28	
uncultured archaeon S30-29	
uncultured archaeon S30-3	
uncultured archaeon S30-30	
uncultured archaeon S30-4	
uncultured archaeon S30-5	
uncultured archaeon S30-6	
uncultured archaeon S30-7	
uncultured archaeon S30-8	
uncultured archaeon S30-9	
uncultured archaeon SAGMA-1	
uncultured archaeon SAGMA-10	
uncultured archaeon SAGMA-11	
uncultured archaeon SAGMA-12	
uncultured archaeon SAGMA-13	
uncultured archaeon SAGMA-14	
uncultured archaeon SAGMA-15	
uncultured archaeon SAGMA-16	
uncultured archaeon SAGMA-17	
uncultured archaeon SAGMA-2	
uncultured archaeon SAGMA-3	
uncultured archaeon SAGMA-4	
uncultured archaeon SAGMA-6	
uncultured archaeon SAGMA-7	
uncultured archaeon SAGMA-8	
uncultured archaeon SAGMA-9	
uncultured archaeon SAGMA-A	
uncultured archaeon SAGMA-B	
uncultured archaeon SAGMA-C	
uncultured archaeon SAGMA-D	
uncultured archaeon SAGMA-E	
uncultured archaeon SAGMA-F	
uncultured archaeon SAGMA-G	
uncultured archaeon SAGMA-H	
uncultured archaeon SAGMA-I	
uncultured archaeon SAGMA-J	
uncultured archaeon SAGMA-J2	

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Name of Unclassified Species	Taxonomy ID
uncultured archaeon SAGMA-K	
uncultured archaeon SAGMA-L	
uncultured archaeon SAGMA-M	
uncultured archaeon SAGMA-N	
uncultured archaeon SAGMA-O	
uncultured archaeon SAGMA-P	
uncultured archaeon SAGMA-Q	
uncultured archaeon SAGMA-R	
uncultured archaeon SAGMA-S	
uncultured archaeon SAGMA-T	
uncultured archaeon SAGMA-U	
uncultured archaeon SAGMA-V	
uncultured archaeon SAGMA-W	
uncultured archaeon SAGMA-X	
uncultured archaeon SAGMA-Y	
uncultured archaeon SAGMA-Z	
uncultured archaeon SC1	
uncultured archaeon SC2	
uncultured archaeon SC4	
uncultured archaeon SC6	
uncultured archaeon SC7	
uncultured archaeon SJC-11b	
uncultured archaeon SJC-125a	
uncultured archaeon SJD-102	
uncultured archaeon SJD-103	
uncultured archaeon SJD-105	
uncultured archaeon SJD-107	
uncultured archaeon SJD-111	
uncultured archaeon SJD-114	
uncultured archaeon SL-C	
uncultured archaeon SL1-1	
uncultured archaeon SL2-d	
uncultured archaeon SM1	
uncultured archaeon SM1K20	
uncultured archaeon ST1-1	
uncultured archaeon ST1-10	
uncultured archaeon ST1-11	
uncultured archaeon ST1-12	

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Name of Unclassified Species	Taxonomy ID
uncultured archaeon ST1-13	
uncultured archaeon ST1-14	
uncultured archaeon ST1-15	
uncultured archaeon ST1-16	
uncultured archaeon ST1-17	
uncultured archaeon ST1-18	
uncultured archaeon ST1-19	
uncultured archaeon ST1-2	
uncultured archaeon ST1-20	
uncultured archaeon ST1-21	
uncultured archaeon ST1-22	
uncultured archaeon ST1-23	
uncultured archaeon ST1-24	
uncultured archaeon ST1-25	
uncultured archaeon ST1-26	
uncultured archaeon ST1-27	
uncultured archaeon ST1-28	
uncultured archaeon ST1-29	
uncultured archaeon ST1-3	
uncultured archaeon ST1-30	
uncultured archaeon ST1-4	
uncultured archaeon ST1-5	
uncultured archaeon ST1-6	
uncultured archaeon ST1-7	
uncultured archaeon ST1-8	
uncultured archaeon ST1-9	
uncultured archaeon SW1	
uncultured archaeon SW14	
uncultured archaeon SW3	
uncultured archaeon SW9	
uncultured archaeon SWY	
uncultured archaeon SYA-1	
uncultured archaeon SYA-106	
uncultured archaeon SYA-112	
uncultured archaeon SYA-12	
uncultured archaeon SYA-122	
uncultured archaeon SYA-125	
uncultured archaeon SYA-127	

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	Name of Unclassified Species	Taxonomy ID
5	uncultured archaeon SYA-13	
	uncultured archaeon SYA-130	
	uncultured archaeon SYA-133	
	uncultured archaeon SYA-136	
10	uncultured archaeon SYA-141	
	uncultured archaeon SYA-20	
	uncultured archaeon SYA-26	
15	uncultured archaeon SYA-30	
	uncultured archaeon SYA-32	
	uncultured archaeon SYA-39	
	uncultured archaeon SYA-45	
20	uncultured archaeon SYA-5	
	uncultured archaeon SYA-50	
	uncultured archaeon SYA-62	
25	uncultured archaeon SYA-7	
	uncultured archaeon SYA-70	
	uncultured archaeon SYA-74	
	uncultured archaeon SYA-75	
30	uncultured archaeon SYA-77	
	uncultured archaeon SYA-78	
	uncultured archaeon SYA-8	
35	uncultured archaeon SYA-80	
	uncultured archaeon SYA-81	
	uncultured archaeon SYA-94	
40	uncultured archaeon SYA_2000_10	
	uncultured archaeon SYA_2000_11	
	uncultured archaeon SYA_2000_12	
	uncultured archaeon SYA_2000_13	
45	uncultured archaeon SYA_2000_14	
	uncultured archaeon SYA 2000 15	
	uncultured archaeon SYA_2000_16	
	uncultured archaeon SYA_2000_17	
50	uncultured archaeon SYA_2000_18	
	uncultured archaeon SYA_2000_19	
	uncultured archaeon SYA_2000_2	
55	uncultured archaeon SYA_2000_20	
	uncultured archaeon SYA_2000_21	
	uncultured archaeon SYA_2000_24	

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	Name of Unclassified Species	Taxonomy ID
5	uncultured archaeon SYA_2000_26	
	uncultured archaeon SYA_2000_27	
	uncultured archaeon SYA_2000_28	
	uncultured archaeon SYA_2000_30	
10	uncultured archaeon SYA_2000_31	
	uncultured archaeon SYA_2000_32	
	uncultured archaeon SYA_2000_35	
15	uncultured archaeon SYA_2000_36	
	uncultured archaeon SYA_2000_37	
	uncultured archaeon SYA_2000_39	
	uncultured archaeon SYA_2000_40	
20	uncultured archaeon SYA_2000_41	
	uncultured archaeon SYA_2000_43	
	uncultured archaeon SYA_2000_44	
25	uncultured archaeon SYA_2000_45	
	uncultured archaeon SYA_2000_46	
	uncultured archaeon SYA_2000_47	
	uncultured archaeon SYA_2000_5	
30	uncultured archaeon SYA_2000_51	
	uncultured archaeon SYA_2000_52	
	uncultured archaeon SYA_2000_54	
35	uncultured archaeon SYA_2000_55	
	uncultured archaeon SYA_2000_57	
	uncultured archaeon SYA_2000_58	
	uncultured archaeon SYA_2000_59	
40	uncultured archaeon SYA_2000_6	
	uncultured archaeon SYA_2000_60	
	uncultured archaeon SYA_2000_61	
45	uncultured archaeon SYA_2000_62	
	uncultured archaeon SYA_2000_63	
	uncultured archaeon SYA_2000_66	
	uncultured archaeon SYA_2000_67	
50	uncultured archaeon SYA_2000_68	
	uncultured archaeon SYA_2000_7	
	uncultured archaeon SYA_2000_70	
55	uncultured archaeon SYA_2000_8	
	uncultured archaeon SYA_2000_9	
	uncultured archaeon TA01	

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Name of Unclassified Species	Taxonomy ID
uncultured archaeon TA02	
uncultured archaeon TA03	
uncultured archaeon TA04	
uncultured archaeon TA05	
uncultured archaeon VC2.1 Arc1	
uncultured archaeon VC2.1 Arc13	
uncultured archaeon VC2.1 Arc16	
uncultured archaeon VC2.1 Arc2	
uncultured archaeon VC2.1 Arc31	
uncultured archaeon VC2.1 Arc35	
uncultured archaeon VC2.1 Arc36	
uncultured archaeon VC2.1 Arc4	
uncultured archaeon VC2.1 Arc5	
uncultured archaeon VC2.1 Arc6	
uncultured archaeon VC2.1 Arc7	
uncultured archaeon VC2.1 Arc8	
uncultured archaeon WSB-1	
uncultured archaeon WSB-10	
uncultured archaeon WSB-11	
uncultured archaeon WSB-12	
uncultured archaeon WSB-13	
uncultured archaeon WSB-14	
uncultured archaeon WSB-15	
uncultured archaeon WSB-16	
uncultured archaeon WSB-17	
uncultured archaeon WSB-18	
uncultured archaeon WSB-19	
uncultured archaeon WSB-2	
uncultured archaeon WSB-20	
uncultured archaeon WSB-21	
uncultured archaeon WSB-3	
uncultured archaeon WSB-4	
uncultured archaeon WSB-5	
uncultured archaeon WSB-6	
uncultured archaeon WSB-7	
uncultured archaeon WSB-8	
uncultured archaeon WSB-9	
uncultured archeon 'KTK 18A'	

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Name of Unclassified Species	Taxonomy ID
uncultured archeon 'KTK 28A'	
uncultured archeon 'KTK 31A'	
uncultured archeon 'KTK 4A'	
uncultured archeon 'KTK 9A'	
uncultured Banisveld landfill archaeon BVlowarchb2	
uncultured Banisveld landfill archaeon BVupparchb1	
uncultured compost archaeon	
uncultured deep-sea archaeon	
uncultured endolithic archaeon	
uncultured equine intestinal archaeal sp. DL11	
uncultured maize rhizosphere archaeon c9_45(Cr)	
uncultured maize root archaeon ZmrA1	
uncultured maize root archaeon ZmrA19	
uncultured maize root archaeon ZmrA30	
uncultured maize root archaeon ZmrA38	
uncultured maize root archaeon ZmrA4	
uncultured maize root archaeon ZmrA42	
uncultured marine archaeon	
uncultured marine archaeon DCM3921	
uncultured marine archaeon DCM6515	
uncultured marine archaeon DCM65231	
uncultured marine archaeon DCM74159	
uncultured marine archaeon DCM74161	
uncultured marine archaeon DCM858	
uncultured marine archaeon DCM860	
uncultured marine archaeon DCM861	
uncultured marine archaeon DCM862	
uncultured marine archaeon DCM863	
uncultured marine archaeon DCM865	
uncultured marine archaeon DCM866	
uncultured marine archaeon DCM867	
uncultured marine archaeon DCM871	
uncultured marine archaeon DCM873	
uncultured marine archaeon DCM874	
uncultured marine archaeon DCM875	
uncultured marine archaeon FF619	
uncultured marine archaeon FF620	
uncultured marine archaeon FIN625	

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	Name of Unclassified Species	Taxonomy ID
5	uncultured marine archaeon FIN654	
	uncultured marine archaeon GIN492	
	uncultured marine archaeon TS10C286	
	uncultured marine archaeon TS10C294	
10	uncultured marine archaeon TS10C298	
	uncultured marine archaeon TS10C299	
	uncultured marine archaeon TS235C302	
15	uncultured marine archaeon TS235C306	
	uncultured marine archaeon TS235C310	
	uncultured methane-oxidizing archaeon	
	uncultured methanogen R5	
20	uncultured methanogen R8	
	uncultured methanogen R9	
	uncultured rumen archaeon	
25	uncultured rumen archaeon M1	
	uncultured rumen archaeon M2	
	uncultured rumen archaeon M7	
	uncultured rumen methanogen	
30	uncultured rumen methanogen 15	
	uncultured rumen methanogen 2	
	uncultured rumen methanogen 956	
35	uncultured rumen methanogen Hole9	
	uncultured rumen methanogen M6	
	uncultured soil archaeon	
	uncultured sponge symbiont PAAR2	
40	uncultured sponge symbiont PAAR4	
	uncultured sponge symbiont PAAR8	
	uncultured sponge symbiont PAAR9	
45	uncultured thermal soil archaeon	
	uncultured vent archaeon	
	unidentified archaeon	
	unidentified archaeon H1-B1	
50	unidentified archaeon H1-K16	
	unidentified archaeon H1-K19	
	unidentified archaeon H1-K2	
55	unidentified archaeon H1-K9	
	unidentified archaeon H6-B1	
	unidentified archaeon H6-K5	

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Name of Unclassified Species	Taxonomy ID
unidentified archaeon H6-K6	
unidentified archaeon HB3-1	
unidentified archaeon S3-K14	
unidentified archaeon S3-K15	
unidentified archaeon S3-K25	
unidentified archaeon S3-K5	
unidentified archaeon S3-K9	
unidentified hydrothermal vent archaeon PVA_OTU_1	
unidentified hydrothermal vent archaeon PVA_OTU_3	
unidentified marine archaeon p712-12	
unidentified marine archaeon p712-13	
unidentified marine archaeon p712-24	
unidentified marine archaeon p712-3	
unidentified marine archaeon p712-37	
unidentified marine archaeon p712-63	

TABLE 4

Class	Order	Family	Genus	Species	Taxonomy ID
Thermoprotei	Caldisphaerales	Caldisphaeraceae	Caldisphaera	draconis	671066
Thermoprotei	Caldisphaerales	Caldisphaeraceae	Caldisphaera	lagunensis	200415
Thermoprotei	Caldisphaerales	Caldisphaeraceae	Caldisphaera		282527
Thermoprotei	Desulfurococcales	Desulfurococcaceae	Acidilobus	aceticus	105851
Thermoprotei	Desulfurococcales	Desulfurococcaceae	Acidilobus	saccharovorans	666510
Thermoprotei	Desulfurococcales	Desulfurococcaceae	Acidilobus	sulfureducens	411357
Thermoprotei	Desulfurococcales	Desulfurococcaceae	Acidilobus	sp. 124-87	242702
Thermoprotei	Desulfurococcales	Desulfurococcaceae	Acidilobus	sp. 405-16	242704
Thermoprotei	Desulfurococcales	Desulfurococcaceae	Acidilobus	sp. 722-67	242705
Thermoprotei	Desulfurococcales	Desulfurococcaceae	Acidilobus		242694
Thermoprotei	Fervidicoccales	Fervidicoccaceae	Fervidicoccus	fontis	683846
Thermoprotei	Sulfolobales	Sulfolobaceae	Acidianus	ambivalens	2283
Thermoprotei	Sulfolobales	Sulfolobaceae	Acidianus	brierleyi	41673
Thermoprotei	Sulfolobales	Sulfolobaceae	Acidianus	convivator	269667
Thermoprotei	Sulfolobales	Sulfolobaceae	Acidianus	hospitalis	563177
Thermoprotei	Sulfolobales	Sulfolobaceae	Acidianus	infernus	12915
Thermoprotei	Sulfolobales	Sulfolobaceae	Acidianus	manzaensis	282676
Thermoprotei	Sulfolobales	Sulfolobaceae	Acidianus	pozzuoliensis	314564
Thermoprotei	Sulfolobales	Sulfolobaceae	Acidianus	sulfidivorans	619593
Thermoprotei	Sulfolobales	Sulfolobaceae	Acidianus	tengchongensis	146920
Thermoprotei	Sulfolobales	Sulfolobaceae	Acidianus	sp. Acii18	315459
Thermoprotei	Sulfolobales	Sulfolobaceae	Acidianus	sp. Acii19	315462
Thermoprotei	Sulfolobales	Sulfolobaceae	Acidianus	sp. Acii25	315461
Thermoprotei	Sulfolobales	Sulfolobaceae	Acidianus	sp. Acii26	315460
Thermoprotei	Sulfolobales	Sulfolobaceae	Acidianus	sp. BT	513519

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Class	Order	Family	Genus	Species	Taxonomy ID
Thermoprotei	Sulfolobales	Sulfolobaceae	Acidianus	sp. F28	315458
Thermoprotei	Sulfolobales	Sulfolobaceae	Acidianus		310069
Thermoprotei	Thermoproteales	Thermofilaceae	Thermofilum	librum	54255
Thermoprotei	Thermoproteales	Thermofilaceae	Thermofilum	pendens	368408
Thermoprotei	Thermoproteales	Thermofilaceae	Thermofilum	sp. 1505	697581
Thermoprotei	Thermoproteales	Thermofilaceae	Thermofilum		310083
Thermoprotei	Unclassified	Unclassified	Unclassified	Unclassified	476105
Unclassified	Unclassified	Unclassified	Candidatus Nitrosocaldus	yellowstonii	498375
Unclassified	Unclassified	Unclassified	Candidatus Nitrosocaldus	Unclassified	766501
Unclassified	Unclassified	Unclassified	Candidatus Nitrososphaera	gargensis	497727
Unclassified	Unclassified	Unclassified	Candidatus Nitrososphaera	Unclassified	759874
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote 768-28	242701
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote OIA-40	161243
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote OIA-444	161244
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote OIA-592	161245
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote OIA-6	161242
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote SRI-298	132570
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote symbiont of Axinella damicornis	171717
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote symbiont of Axinella verrucosa	171716
Unclassified	Unclassified	Unclassified	Unclassified	marine crenarchaeote RS.Sph.032	340702
Unclassified	Unclassified	Unclassified	Unclassified	marine crenarchaeote RS.Sph.033	340703
Unclassified	Unclassified	Unclassified	Unclassified	Octopus Spring nitrifying crenarchaeote OS70	498372
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote symbiont of Axinella sp.	173517
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment clone CUL T1196a	442104

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Class	Order	Family	Genus	Species	Taxonomy ID
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment clone CULT1196b	442105
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment clone CULT1198a	442106
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment clone CULT1219a	442107
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment clone CULT1224a	442108
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment clone CULT1225a	442109
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment clone CULT1231a	442112
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment clone CULT1233a	442110
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment clone CULT1537a	442111
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment clone CULT1537b	442113
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment clone CULT1539a	442114
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment clone CULT1572a	442115
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment clone CULT1580a	442116
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment clone CULT1581a	442117
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment clone CULT1587a	442119
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment clone CULT1592a	442118
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment clone F81	485627
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA10-A01	550545
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA10-A02	550546
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA10-A03	550547
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA10-B01	550548
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA10-B02	550549
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA10-B03	550550
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA10-C01	550551
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA10-C02	550552
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA10-C03	550553

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Class	Order	Family	Genus	Species	Taxonomy ID
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA10-D01	550554
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA10-D02	550555
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA10-D03	550556
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA10-E01	550557
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA10-E02	550558
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA10-E03	550559
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA10-F01	550560
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA10-F02	550561
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA10-F03	550562
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA10-G01	550563
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA10-G02	550564
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA10-G03	550565
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA10-H01	550566
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA10-H02	550567
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA10-H03	550568
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA41-A01	550569
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA41-A02	550570
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA41-B01	550572
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA41-B02	550573
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA41-C01	550575
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA41-C02	550576
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA41-D01	550578
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA41-D02	550579
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA41-E01	550581
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA41-F01	550584

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Class	Order	Family	Genus	Species	Taxonomy ID
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA41-F02	550585
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA41-G01	550587
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA41-G02	550588
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA41-H01	550590
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BA41-H02	550591
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BC11-A01	550593
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BC11-A02	550594
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BC11-B01	550596
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BC11-B02	550597
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BC11-C01	550599
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BC11-C02	550600
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BC11-D01	550601
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BC11-D02	550602
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BC11-E01	550603
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BC11-E02	550604
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BC11-F01	550606
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BC11-F02	550607
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BC11-G01	550609
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BC11-G02	550610
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BC11-H01	550612
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BC11-H02	550613
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BD31-A01	550615
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BD31-A02	550616
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BD31-B01	550618
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BD31-B02	550619

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Class	Order	Family	Genus	Species	Taxonomy ID
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BD31-C01	550621
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BD31-C02	550622
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BD31-D01	550624
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BD31-D02	550625
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BD31-E01	550627
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BD31-E02	550628
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BD31-F01	550630
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BD31-F02	550631
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BD31-G01	550633
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BD31-G02	550634
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BD31-H01	550636
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BD31-H02	550637
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BG30-A01	550639
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BG30-A02	550640
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BG30-A03	550641
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BG30-B01	550642
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BG30-B02	550643
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BG30-C01	550644
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BG30-C02	550645
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BG30-C03	550646
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BG30-D01	550647
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BG30-D02	550648
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BG30-E01	550649
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BG30-E02	550650
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BG30-F01	550651

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Class	Order	Family	Genus	Species	Taxonomy ID
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BG30-F02	550652
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BG30-F03	550653
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BG30-G01	550654
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BG30-G02	550655
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BG30-G03	550656
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BG30-H01	550657
Unclassified	Unclassified	Unclassified	Unclassified	crenarchaeote enrichment culture clone SF06E-BG30-H02	550658
Unclassified	Unclassified	Unclassified	Unclassified	planktonic crenarchaeote	110442
Unclassified	Unclassified	Unclassified	Unclassified	unculturable Mariana archaeon no. 1	73126
Unclassified	Unclassified	Unclassified	Unclassified	unculturable Mariana archaeon no. 11	73127
Unclassified	Unclassified	Unclassified	Unclassified	unculturable Mariana archaeon no. 15	73128
Unclassified	Unclassified	Unclassified	Unclassified	uncultured ammonia-oxidizing crenarchaeote	666997
Unclassified	Unclassified	Unclassified	Unclassified	uncultured archaeon WCHA1-38	74272
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Crater Lake archaeon CL500-AR1	148262
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Crater Lake archaeon CL500-AR12	148263
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote	29281
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote 10-H-08	311458
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote 29d5	684057
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote 57a5	684058
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote 76h13	684059
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote AM-20A 101	115035
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote AM-20A_102	115036
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote AM-20A_103	115037
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote AM-20A_104	115038
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote AM-20A_117	115039

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Class	Order	Family	Genus	Species	Taxonomy ID
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote AT-200_1	115040
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote AT-200_7	115041
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote AT-5_1	115042
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote CA-15_P18	115043
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote DeepAnt-EC39	247023
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote DN-200_1	115044
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote DN-5_1	115045
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote DS-5_1	115046
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote DS-5_P21	115047
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote FFSC1	78160
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote FFSC2	77776
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote FFSC3	78161
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote FFSC4	78162
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote FRD0	88890
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote	75613
				KBSCul1	
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote KBSCul13	75618
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote KBSCul4	75614
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote KBSCul5	75615
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote KBSCul7	75616
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote KBSCul9	75617
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote KBSNat1	75619
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote KBSNat11	75622
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote KBSNat12	75623
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote KBSNat2	75620

(continued)

Class	Order	Family	Genus	Species	Taxonomy ID
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote KBSNat20	75624
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote KBSNat4	75621
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote MCG	529375
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote ME-450 20	115048
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote ME-450_5	115049
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote ME-450_9	115050
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote ME-450_P3	115051
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote ME-450_P5	115052
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote ODPB-A12	95929
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote ODPB-A18	95930
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote ODPB-A2	95924
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote ODPB-A3	95925
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote ODPB-A6	95926
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote ODPB-A7	95927
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote ODPB-A9	95928
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote pBRKC108	91318
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote pBRKC125	91319
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote pBRKC129	91315
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote pBRKC135	91314
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote pBRKC82	91316
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote pBRKC86	91313
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote pBRKC88	91317
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote SB95_1	115053
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote SB95_20	115054
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote TRC132-3	115020

(continued)

Class	Order	Family	Genus	Species	Taxonomy ID
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote TRC132-6	115021
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote	115022
				TRC132-7	
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote TRC132-8	115023
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote TRC132-9	115024
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote TRC23-10	115025
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote TRC23-28	115026
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote TRC23-30	115027
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote TRC23-31	115028
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote TRC23-38	115029
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote TREC16-1	258888
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote TREC16-10	258884
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote TREC16-12	258883
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote TREC16-14	258882
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote TREC16-16	258880
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote TREC16-18	258881
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote TREC16-3	258887
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote TREC16-6	258886
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote TREC16-9	258885
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote TREC89-10	258879
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote TREC89-11	258878
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote TREC89-136	258870
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote TREC89-17	258874
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote TREC89-20	258877
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote TREC89-24	258876

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Class	Order	Family	Genus	Species	Taxonomy ID
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote TREC89-30	258875
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote TREC89-34	258873
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote TREC89-36	258872
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote TREC89-44	258871
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote VAL11	85495
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote VAL114	85494
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote VAL151	85499
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote VAL159	85504
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote VAL18	85496
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote VAL20	85500
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote VAL29	85503
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote VAL42	85501
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote VAL48	85502
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote	85505
				VAL76	
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote VAL81	85498
Unclassified	Unclassified	Unclassified	Unclassified	uncultured crenarchaeote VAL96	85497
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRA0	147499
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRA1	147500
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRA27	147501
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRA27x2	147502
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRA31B	147503
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRA32	147504
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRA33	147505
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRA9	147506

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Class	Order	Family	Genus	Species	Taxonomy ID
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRB1	147507
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRB15	147508
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRB25	147509
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRB27	147510
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRB31	147512
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRB32B	147511
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRB32x2	147513
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRB33	147514
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRB38	147515
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRB9A	147516
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRC0	147517
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRC15	147518
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRC1B	147519
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRC1x2	147520
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRC27	147521
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRC32	147522
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRC33A	147523
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRC33B	147524
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRC38	147525
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRC9	147526
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRD0	147527
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRD15	147528
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRD25B	147529
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRD25x2	147530
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRD31	147531

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Class	Order	Family	Genus	Species	Taxonomy ID
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil	147532
				crenarchaeote FRD32	
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRD33	147533
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRD38	147534
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRD9	147535
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Front Range soil crenarchaeote FRD9x2	147536
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Green Bay ferromanganous micronodule archaeon ARA7	140618
Unclassified	Unclassified	Unclassified	Unclassified	uncultured Green Bay ferromanganous micronodule archaeon ARC12	140619
Unclassified	Unclassified	Unclassified	Unclassified	uncultured marine archaeon AEGEAN_56	147159
Unclassified	Unclassified	Unclassified	Unclassified	uncultured marine archaeon AEGEAN_67	147162
Unclassified	Unclassified	Unclassified	Unclassified	uncultured marine archaeon AEGEAN_69	147160
Unclassified	Unclassified	Unclassified	Unclassified	uncultured marine archaeon AEGEAN_70	147161
Unclassified	Unclassified	Unclassified	Unclassified	uncultured marine crenarchaeote	115413
Unclassified	Unclassified	Unclassified	Unclassified	uncultured marine group I crenarchaeote	360837
Unclassified	Unclassified	Unclassified	Unclassified	unidentified archaeon Antarctic12	33863
Unclassified	Unclassified	Unclassified	Unclassified	unidentified archaeon Antarctic5	33864
Unclassified	Unclassified	Unclassified	Unclassified	unidentified archaeon C11	52260
Unclassified	Unclassified	Unclassified	Unclassified	unidentified archaeon C20	52261
Unclassified	Unclassified	Unclassified	Unclassified	unidentified archaeon C33	52262
Unclassified	Unclassified	Unclassified	Unclassified	unidentified archaeon C35	52263
Unclassified	Unclassified	Unclassified	Unclassified	unidentified archaeon C46	52264
Unclassified	Unclassified	Unclassified	Unclassified	unidentified archaeon C48	52265
Unclassified	Unclassified	Unclassified	Unclassified	unidentified archaeon C6	52266
Unclassified	Unclassified	Unclassified	Unclassified	unidentified archaeon ICHT	43688

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Class	Order	Family	Genus	Species	Taxonomy ID
Unclassified	Unclassified	Unclassified	Unclassified	unidentified archaeon LMA137	57672
Unclassified	Unclassified	Unclassified	Unclassified	unidentified archaeon LMA226	57674
Unclassified	Unclassified	Unclassified	Unclassified	unidentified archaeon LMA229	57673
Unclassified	Unclassified	Unclassified	Unclassified	unidentified archaeon LMA238	57671
Unclassified	Unclassified	Unclassified	Unclassified	unidentified archaeon OARB	33862
Unclassified	Unclassified	Unclassified	Unclassified	unidentified archaeon PM23	52267
Unclassified	Unclassified	Unclassified	Unclassified	unidentified archaeon PM7	52268
Unclassified	Unclassified	Unclassified	Unclassified	unidentified archaeon PM8	52269
Unclassified	Unclassified	Unclassified	Unclassified	unidentified archaeon SCA11	50858
Unclassified	Unclassified	Unclassified	Unclassified	unidentified archaeon SCA1145	50793
Unclassified	Unclassified	Unclassified	Unclassified	unidentified archaeon SCA1150	50850
Unclassified	Unclassified	Unclassified	Unclassified	unidentified archaeon SCA1151	50851
Unclassified	Unclassified	Unclassified	Unclassified	unidentified archaeon SCA1154	50852
Unclassified	Unclassified	Unclassified	Unclassified	unidentified archaeon SCA1158	50853
Unclassified	Unclassified	Unclassified	Unclassified	unidentified archaeon SCA1166	50854
Unclassified	Unclassified	Unclassified	Unclassified	unidentified archaeon SCA1170	50855
Unclassified	Unclassified	Unclassified	Unclassified	unidentified archaeon SCA1173	50856
Unclassified	Unclassified	Unclassified	Unclassified	unidentified archaeon SCA1175	50857
Unclassified	Unclassified	Unclassified	Unclassified	unidentified hydrothermal vent archaeon PVA_OTU_2	45967
Unclassified	Unclassified	Unclassified	Unclassified	unidentified hydrothermal vent archaeon PVA_OTU_4	45969

TABLE 5

	Name of Unclassified Species	Taxonomy ID
5	crenarchaeote 768-28	(242701)
	crenarchaeote OIA-40	(161243)
	crenarchaeote OIA-444	(161244)
	crenarchaeote OIA-592	(161245)
10	crenarchaeote OIA-6	(161242)
	crenarchaeote SRI-298	(132570)
	crenarchaeote symbiont of Axinella damicornis	(171717)
15	crenarchaeote symbiont of Axinella verrucosa	(171716)
	marine crenarchaeote RS.Sph.032	(340702)
	marine crenarchaeote RS.Sph.033	(340703)
20	Octopus Spring nitrifying crenarchaeote OS70	(498372)
	crenarchaeote symbiont of Axinella sp.	(173517)
	crenarchaeote enrichment clone CULT1196a	(442104)
	crenarchaeote enrichment clone CULT1196b	(442105)
25	crenarchaeote enrichment clone CULT1198a	(442106)
	crenarchaeote enrichment clone CULT1219a	(442107)
	crenarchaeote enrichment clone CULT1224a	(442108)
	crenarchaeote enrichment clone CULT1225a	(442109)
30	crenarchaeote enrichment clone CULT1231a	(442112)
	crenarchaeote enrichment clone CULT1233a	(442110)
	crenarchaeote enrichment clone CULT1537a	(442111)
35	crenarchaeote enrichment clone CULT1537b	(442113)
	crenarchaeote enrichment clone CULT1539a	(442114)
	crenarchaeote enrichment clone CULT1572a	(442115)
40	crenarchaeote enrichment clone CULT1580a	(442116)
	crenarchaeote enrichment clone CULT1581a	(442117)
	crenarchaeote enrichment clone CULT1587a	(442119)
	crenarchaeote enrichment clone CULT1592a	442118)
45	crenarchaeote enrichment clone F81	485627
	crenarchaeote enrichment culture clone SF06E-BA10-A01	550545
	crenarchaeote enrichment culture clone SF06E-BA10-A02	550546
50	crenarchaeote enrichment culture clone SF06E-BA10-A03	550547
	crenarchaeote enrichment culture clone SF06E-BA10-B01	550548)
	crenarchaeote enrichment culture clone SF06E-BA10-B02	550549)
	crenarchaeote enrichment culture clone SF06E-BA10-B03	550550)
55	crenarchaeote enrichment culture clone SF06E-BA10-C01	550551)
	crenarchaeote enrichment culture clone SF06E-BA10-C02	550552)

(continued)

	Name of Unclassified Species	Taxonomy ID
5	crenarchaeote enrichment culture clone SF06E-BA10-C03	550553)
	crenarchaeote enrichment culture clone SF06E-BA10-D01	550554)
	crenarchaeote enrichment culture clone SF06E-BA10-D02	550555)
	crenarchaeote enrichment culture clone SF06E-BA10-D03	550556)
10	crenarchaeote enrichment culture clone SF06E-BA10-E01	550557)
	crenarchaeote enrichment culture clone SF06E-BA10-E02	550558)
	crenarchaeote enrichment culture clone SF06E-BA10-E03	550559)
15	crenarchaeote enrichment culture clone SF06E-BA10-F01	550560)
	crenarchaeote enrichment culture clone SF06E-BA10-F02	550561)
	crenarchaeote enrichment culture clone SF06E-BA10-F03	550562)
20	crenarchaeote enrichment culture clone SF06E-BA10-G01	550563)
	crenarchaeote enrichment culture clone SF06E-BA10-G02	550564)
	crenarchaeote enrichment culture clone SF06E-BA10-G03	550565)
25	crenarchaeote enrichment culture clone SF06E-BA10-H01	550566)
	crenarchaeote enrichment culture clone SF06E-BA10-H02	550567)
	crenarchaeote enrichment culture clone SF06E-BA10-H03	550568)
30	crenarchaeote enrichment culture clone SF06E-BA41-A01	550569)
	crenarchaeote enrichment culture clone SF06E-BA41-A02	550570)
	crenarchaeote enrichment culture clone SF06E-BA41-B01	550572)
35	crenarchaeote enrichment culture clone SF06E-BA41-B02	550573)
	crenarchaeote enrichment culture clone SF06E-BA41-C01	550575)
	crenarchaeote enrichment culture clone SF06E-BA41-C02	550576)
40	crenarchaeote enrichment culture clone SF06E-BA41-D01	550578)
	crenarchaeote enrichment culture clone SF06E-BA41-D02	550579)
	crenarchaeote enrichment culture clone SF06E-BA41-E01	550581)
45	crenarchaeote enrichment culture clone SF06E-BA41-F01	550584)
	crenarchaeote enrichment culture clone SF06E-BA41-F02	550585)
	crenarchaeote enrichment culture clone SF06E-BA41-G01	550587)
50	crenarchaeote enrichment culture clone SF06E-BA41-G02	550588)
	crenarchaeote enrichment culture clone SF06E-BA41-H01	550590)
	crenarchaeote enrichment culture clone SF06E-BA41-H02	550591)
55	crenarchaeote enrichment culture clone SF06E-BC11-A01	550593)
	crenarchaeote enrichment culture clone SF06E-BC11-A02	550594)
	crenarchaeote enrichment culture clone SF06E-BC11-B01	550596)
	crenarchaeote enrichment culture clone SF06E-BC11-B02	550597)
	crenarchaeote enrichment culture clone SF06E-BC11-C01	550599)
	crenarchaeote enrichment culture clone SF06E-BC11-C02	550600)
	crenarchaeote enrichment culture clone SF06E-BC11-D01	550601)

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	Name of Unclassified Species	Taxonomy ID
5	crenarchaeote enrichment culture clone SF06E-BC11-D02	550602)
	crenarchaeote enrichment culture clone SF06E-BC11-E01	550603)
	crenarchaeote enrichment culture clone SF06E-BC11-E02	550604)
	crenarchaeote enrichment culture clone SF06E-BC11-F01	550606)
10	crenarchaeote enrichment culture clone SF06E-BC11-F02	550607)
	crenarchaeote enrichment culture clone SF06E-BC11-G01	550609)
	crenarchaeote enrichment culture clone SF06E-BC11-G02	550610)
15	crenarchaeote enrichment culture clone SF06E-BC11-H01	550612)
	crenarchaeote enrichment culture clone SF06E-BC11-H02	550613)
	crenarchaeote enrichment culture clone SF06E-BD31-A01	550615)
	crenarchaeote enrichment culture clone SF06E-BD31-A02	550616)
20	crenarchaeote enrichment culture clone SF06E-BD31-B01	550618)
	crenarchaeote enrichment culture clone SF06E-BD31-B02	550619)
	crenarchaeote enrichment culture clone SF06E-BD31-C01	550621)
25	crenarchaeote enrichment culture clone SF06E-BD31-C02	550622)
	crenarchaeote enrichment culture clone SF06E-BD31-D01	550624)
	crenarchaeote enrichment culture clone SF06E-BD31-D02	550625)
	crenarchaeote enrichment culture clone SF06E-BD31-E01	550627)
30	crenarchaeote enrichment culture clone SF06E-BD31-E02	550628)
	crenarchaeote enrichment culture clone SF06E-BD31-F01	550630)
	crenarchaeote enrichment culture clone SF06E-BD31-F02	550631)
35	crenarchaeote enrichment culture clone SF06E-BD31-G01	550633)
	crenarchaeote enrichment culture clone SF06E-BD31-G02	550634)
	crenarchaeote enrichment culture clone SF06E-BD31-H01	550636)
	crenarchaeote enrichment culture clone SF06E-BD31-H02	550637)
40	crenarchaeote enrichment culture clone SF06E-BG30-A01	550639)
	crenarchaeote enrichment culture clone SF06E-BG30-A02	550640
	crenarchaeote enrichment culture clone SF06E-BG30-A03	550641
45	crenarchaeote enrichment culture clone SF06E-BG30-B01	550642
	crenarchaeote enrichment culture clone SF06E-BG30-B02	550643
	crenarchaeote enrichment culture clone SF06E-BG30-C01	550644
	crenarchaeote enrichment culture clone SF06E-BG30-C02	550645
50	crenarchaeote enrichment culture clone SF06E-BG30-C03	550646
	crenarchaeote enrichment culture clone SF06E-BG30-D01	550647
	crenarchaeote enrichment culture clone SF06E-BG30-D02	550648
55	crenarchaeote enrichment culture clone SF06E-BG30-E01	550649
	crenarchaeote enrichment culture clone SF06E-BG30-E02	550650
	crenarchaeote enrichment culture clone SF06E-BG30-F01	550651

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	Name of Unclassified Species	Taxonomy ID
5	crenarchaeote enrichment culture clone SF06E-BG30-F02	550652
	crenarchaeote enrichment culture clone SF06E-BG30-F03	550653
	crenarchaeote enrichment culture clone SF06E-BG30-G01	550654
	crenarchaeote enrichment culture clone SF06E-BG30-G02	550655
10	crenarchaeote enrichment culture clone SF06E-BG30-G03	550656
	crenarchaeote enrichment culture clone SF06E-BG30-H01	550657
	crenarchaeote enrichment culture clone SF06E-BG30-H02	550658
15	crenarchaeote enrichment culture clone SF06E-BG30-H03	550659
	planktonic crenarchaeote	110442
	unculturable Mariana archaeon no. 1	73126
	unculturable Mariana archaeon no. 11	73127
20	unculturable Mariana archaeon no. 15	73128
	uncultured ammonia-oxidizing crenarchaeote	666997
	uncultured archaeon WCHA1-38	74272
25	uncultured Crater Lake archaeon CL500-AR1	148262
	uncultured Crater Lake archaeon CL500-AR12	148263
	uncultured crenarchaeote	29281
	uncultured crenarchaeote 10-H-08	311458
30	uncultured crenarchaeote 29d5	684057
	uncultured crenarchaeote 57a5	684058
	uncultured crenarchaeote 76h13	684059
35	uncultured crenarchaeote AM-20A_101	115035
	uncultured crenarchaeote AM-20A_102	115036
	uncultured crenarchaeote AM-20A_103	115037
	uncultured crenarchaeote AM-20A_104	115038
40	uncultured crenarchaeote AM-20A_117	115039
	uncultured crenarchaeote AT-200_1	115040
	uncultured crenarchaeote AT-200_7	115041
45	uncultured crenarchaeote AT-5_1	115042
	uncultured crenarchaeote CA-15_P18	115043
	uncultured crenarchaeote DeepAnt-EC39	247023
50	uncultured crenarchaeote DN-200_1	115044
	uncultured crenarchaeote DN-5_1	115045
	uncultured crenarchaeote DS-5_1	115046
	uncultured crenarchaeote DS-5_P21	115047
55	uncultured crenarchaeote FFSC1	78160
	uncultured crenarchaeote FFSC2	77776
	uncultured crenarchaeote FFSC3	78161

(continued)

5	Name of Unclassified Species	Taxonomy ID
	uncultured crenarchaeote FFSC4	78162
	uncultured crenarchaeote FRD0	88890
	uncultured crenarchaeote KBSCul1	75613
	uncultured crenarchaeote KBSCul13	75618
10	uncultured crenarchaeote KBSCul4	75614
	uncultured crenarchaeote KBSCul5	75615
	uncultured crenarchaeote KBSCul7	75616
	uncultured crenarchaeote KBSCul9	75617
	uncultured crenarchaeote KBSNat1	75619
15	uncultured crenarchaeote KBSNat11	75622
	uncultured crenarchaeote KBSNat12	75623
	uncultured crenarchaeote KBSNat2	75620
	uncultured crenarchaeote KBSNat20	75624
	uncultured crenarchaeote KBSNat4	75621
20	uncultured crenarchaeote MCG	529375
	uncultured crenarchaeote ME-450_20	115048
	uncultured crenarchaeote ME-450_5	115049
	uncultured crenarchaeote ME-450_9	115050
	uncultured crenarchaeote ME-450_P3	115051
25	uncultured crenarchaeote ME-450_P5	115052
	uncultured crenarchaeote ODPB-A12	95929
	uncultured crenarchaeote ODPB-A18	95930
	uncultured crenarchaeote ODPB-A2	95924
	uncultured crenarchaeote ODPB-A3	95925
30	uncultured crenarchaeote ODPB-A6	95926
	uncultured crenarchaeote ODPB-A7	95927
	uncultured crenarchaeote ODPB-A9	95928
	uncultured crenarchaeote pBRKC108	91318
	uncultured crenarchaeote pBRKC125	91319
35	uncultured crenarchaeote pBRKC129	91315
	uncultured crenarchaeote pBRKC135	91314
	uncultured crenarchaeote pBRKC82	91316
	uncultured crenarchaeote pBRKC86	91313
	uncultured crenarchaeote pBRKC88	91317
40	uncultured crenarchaeote SB95_1	115053
	uncultured crenarchaeote SB95_20	115054
	uncultured crenarchaeote TRC132-3	115020
	uncultured crenarchaeote TRC132-6	115021

(continued)

	Name of Unclassified Species	Taxonomy ID
5	uncultured crenarchaeote TRC132-7	115022
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	uncultured crenarchaeote TRC23-10	115025
10	uncultured crenarchaeote TRC23-28	115026
	uncultured crenarchaeote TRC23-30	115027
	uncultured crenarchaeote TRC23-31	115028
	uncultured crenarchaeote TRC23-38	115029
15	uncultured crenarchaeote TREC16-1	258888
	uncultured crenarchaeote TREC16-10	258884
	uncultured crenarchaeote TREC16-12	258883
20	uncultured crenarchaeote TREC16-14	258882
	uncultured crenarchaeote TREC16-16	258881
	uncultured crenarchaeote TREC16-18	258880
25	uncultured crenarchaeote TREC16-3	258887
	uncultured crenarchaeote TREC16-6	258886
	uncultured crenarchaeote TREC16-9	258885
	uncultured crenarchaeote TREC89-10	258879
30	uncultured crenarchaeote TREC89-11	258878
	uncultured crenarchaeote TREC89-136	258870
	uncultured crenarchaeote TREC89-17	258874
35	uncultured crenarchaeote TREC89-20	258877
	uncultured crenarchaeote TREC89-24	258876
	uncultured crenarchaeote TREC89-30	258875
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	uncultured crenarchaeote TREC89-44	258871
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	uncultured crenarchaeote VAL151	85499
	uncultured crenarchaeote VAL159	85496
	uncultured crenarchaeote VAL18	85504
50	uncultured crenarchaeote VAL20	85500
	uncultured crenarchaeote VAL29	85503
	uncultured crenarchaeote VAL42	85501
55	uncultured crenarchaeote VAL48	85502
	uncultured crenarchaeote VAL76	85505
	uncultured crenarchaeote VAL81	85498

(continued)

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	uncultured Front Range soil crenarchaeote FRA27	147501
10	uncultured Front Range soil crenarchaeote FRA27x2	147502
	uncultured Front Range soil crenarchaeote FRA31B	147503
	uncultured Front Range soil crenarchaeote FRA32	147504
15	uncultured Front Range soil crenarchaeote FRA33	147505
	uncultured Front Range soil crenarchaeote FRA9	147506
	uncultured Front Range soil crenarchaeote FRB1	147507
	uncultured Front Range soil crenarchaeote FRB15	147508
20	uncultured Front Range soil crenarchaeote FRB25	147509
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	uncultured Front Range soil crenarchaeote FRB31	147511
25	uncultured Front Range soil crenarchaeote FRB32B	147512
	uncultured Front Range soil crenarchaeote FRB32x2	147513
	uncultured Front Range soil crenarchaeote FRB33	147514
	uncultured Front Range soil crenarchaeote FRB38	147515
30	uncultured Front Range soil crenarchaeote FRB9A	147516
	uncultured Front Range soil crenarchaeote FRC0	147517
	uncultured Front Range soil crenarchaeote FRC15	147518
35	uncultured Front Range soil crenarchaeote FRC1B	147519
	uncultured Front Range soil crenarchaeote FRC1x2	147520
	uncultured Front Range soil crenarchaeote FRC27	147521
	uncultured Front Range soil crenarchaeote FRC32	147522
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	uncultured Front Range soil crenarchaeote FRC33B	147524
	uncultured Front Range soil crenarchaeote FRC38	147525
45	uncultured Front Range soil crenarchaeote FRC9	147526
	uncultured Front Range soil crenarchaeote FRD0	147527
	uncultured Front Range soil crenarchaeote FRD15	147528
	uncultured Front Range soil crenarchaeote FRD25B	147529
50	uncultured Front Range soil crenarchaeote FRD25x2	147530
	uncultured Front Range soil crenarchaeote FRD31	147531
	uncultured Front Range soil crenarchaeote FRD32	147532
55	uncultured Front Range soil crenarchaeote FRD33	147533
	uncultured Front Range soil crenarchaeote FRD38	147534
	uncultured Front Range soil crenarchaeote FRD9	147535

(continued)

	Name of Unclassified Species	Taxonomy ID
5	uncultured Front Range soil crenarchaeote FRD9x2	147536
	uncultured Green Bay ferromanganous micronodule archaeon ARA7	140618
	uncultured Green Bay ferromanganous micronodule archaeon ARC12	140619
	uncultured marine archaeon AEGEAN_56	147159
10	uncultured marine archaeon AEGEAN_67	147162
	uncultured marine archaeon AEGEAN_69	147160
	uncultured marine archaeon AEGEAN_70	147161
	uncultured marine crenarchaeote	115413
15	uncultured marine group I crenarchaeote	360837
	unidentified archaeon Antarctic12	33863
	unidentified archaeon Antarctic5	33864
20	unidentified archaeon C11	52260
	unidentified archaeon C20	52261
	unidentified archaeon C33	52262
	unidentified archaeon C35	52263
25	unidentified archaeon C46	52264
	unidentified archaeon C48	52265
	unidentified archaeon C6	52266
30	unidentified archaeon ICHT	43688
	unidentified archaeon LMA137	57672
	unidentified archaeon LMA226	57674
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35	unidentified archaeon LMA238	57671
	unidentified archaeon OARB	33862
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40	unidentified archaeon PM7	52268
	unidentified archaeon PM8	52269
	unidentified archaeon SCA11	50858
45	unidentified archaeon SCA1145	50793
	unidentified archaeon SCA1150	50850
	unidentified archaeon SCA1151	50851
	unidentified archaeon SCA1154	50852
50	unidentified archaeon SCA1158	50853
	unidentified archaeon SCA1166	50854
	unidentified archaeon SCA1170	50855
55	unidentified archaeon SCA1173	50856
	unidentified archaeon SCA1175	50857
	unidentified hydrothermal vent archaeon PVA_OTU_2	45967

(continued)

Name of Unclassified Species	Taxonomy ID
unidentified hydrothermal vent archaeon PVA_OTU_4	45969

REFERENCES CITED IN THE DESCRIPTION

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PATENTKRAV

1. Fremgangsmåde til fremstilling af methan, hvilken fremgangsmåde omfatter:

- (a) tilførsel af elektricitet til en anode (218) og en porøs elektrisk ledende katode (216) af en biologisk reaktor (202), hvor den biologiske reaktor (i) er koblet til en elektricitetskilde (204) og en carbondioxidkilde (206), (ii) har mindst et første kammer (212), der mindst indeholder katoden (216), en kultur, der omfatter methanogene mikroorganismer, og vand, et andet kammer (214), der mindst indeholder anoden (218), og en protonpermeabel, gasimpermeabel barriere (220), som separerer anoden (218) fra katoden (216), og (iii) har en strømaftager (230, 232), der er koblet til hver af anoden (218) og katoden (216), hvor katoden (216) er imprægneret med de methanogene mikroorganismer og med et vandigt elektrolytisk medium, hvor de methanogene mikroorganismer er i en passage (238), som er dannet mellem barrieren (220) og strømaftageren (230), der er koblet til katoden (216), og lokaliseret mellem et indløb til carbondioxid (234) og et udløb til methan (236), hvor kulturen opretholdes i det vandige elektrolytiske medium i passagen (238) i det første kammer (212) ved en temperatur på over 50 °C;
- (b) tilførsel af carbondioxid til det første kammer (212) gennem indløbet (234) i det første kammer (212), hvorpå carbondioxidet opløses i det vandige elektrolytiske medium;
- (c) cirkulering af det vandige elektrolytiske medium, der omfatter det opløste carbondioxid, gennem katoden (216); og
- (d) opsamling af methan fra udløbet (236) i det første kammer (212).

2. Fremgangsmåde ifølge krav 1, hvor kulturen opretholdes ved en temperatur på ca. 55 °C eller derover, valgfrit ca. 60 °C eller derover.

3. Fremgangsmåde ifølge krav 1, hvor kulturen omfatter *Archaea*, der er tilpasset til næsten stationære vækstbetingelser.

4. Fremgangsmåde ifølge krav 1, hvor den biologiske reaktor (202) har en driftstilstand og en hviletilstand, idet reaktoren (202) uden tilsætning af methanogene mikroorganismer skifter fra hviletilstanden til driftstilstanden, valgfrit hvor hviletilstanden forekommer, når den biologiske reaktor (202) er afkoblet fra elektricitetskilden (204) eller

carbondioxidkilden (206).

5. Fremgangsmåde ifølge krav 1, hvor barrieren (220) omfatter en fast polymerelektrolytmembran.
5
6. Fremgangsmåde ifølge krav 1, hvor den porøse elektrisk ledende katode (216) omfatter et retikuleret carbonskum.
7. Fremgangsmåde ifølge krav 1, hvor kulturen omfatter *Archaea* i underriget *Euryarchaeota*, valgfrit hvor kulturen er en monokultur af *Euryarchaeota*.
10
8. Fremgangsmåde ifølge krav 7, hvor *Archaea* består af *Methanothermobacter thermautotrophicus*.
9. Fremgangsmåde ifølge krav 1, hvor strømaftageren, der er koblet til katoden (230), er en fast skive af et materiale, som inden i det første kammer (212) mellem indløbet til carbondioxidet (234) og udløbet til metanen (236) opretholder en tætnet tilstand.
15
10. Fremgangsmåde ifølge krav 1, hvor strømaftageren til anoden (232) definerer et porøst gasdiffusionslag, på hvilket der er anbragt en anodekatalysator, hvor det porøse gasdiffusionslag tillader gasformige biprodukter at forlade det andet kammer (214).
20
11. Fremgangsmåde ifølge krav 1, hvor kulturen forbliver i det cirkulerende vandige elektrolytiske medium.
25
12. Fremgangsmåde ifølge krav 1, hvor kulturen er bundet til den porøse katode (216).
13. Fremgangsmåde ifølge krav 1, hvor vand er en primær nettoelektron donor for de methanogene mikroorganismer.
30
14. Fremgangsmåde ifølge krav 1, hvor der ikke er nogen organisk carbonkilde i mediet.

DRAWINGS

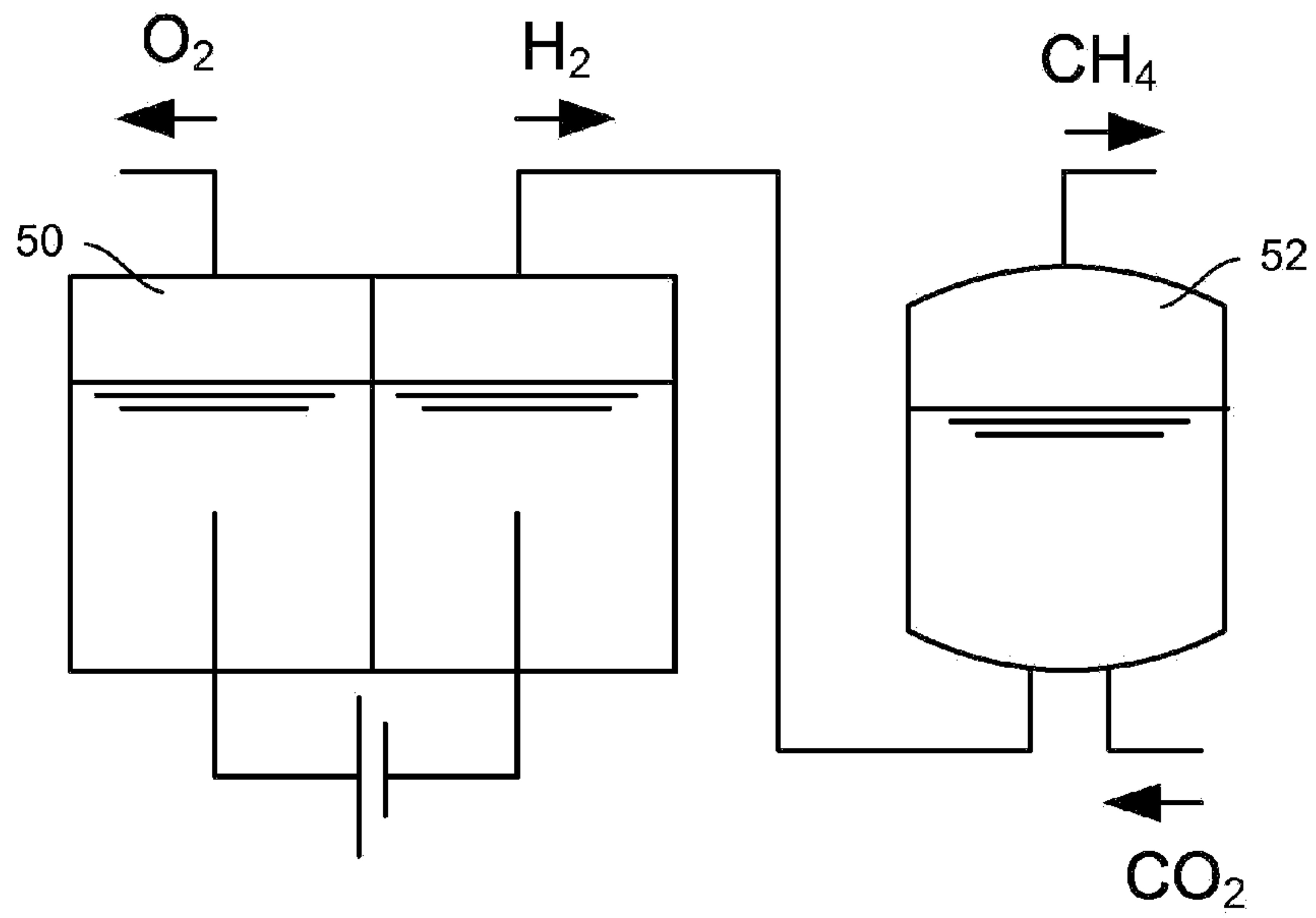
PRIOR ART

FIG. 1

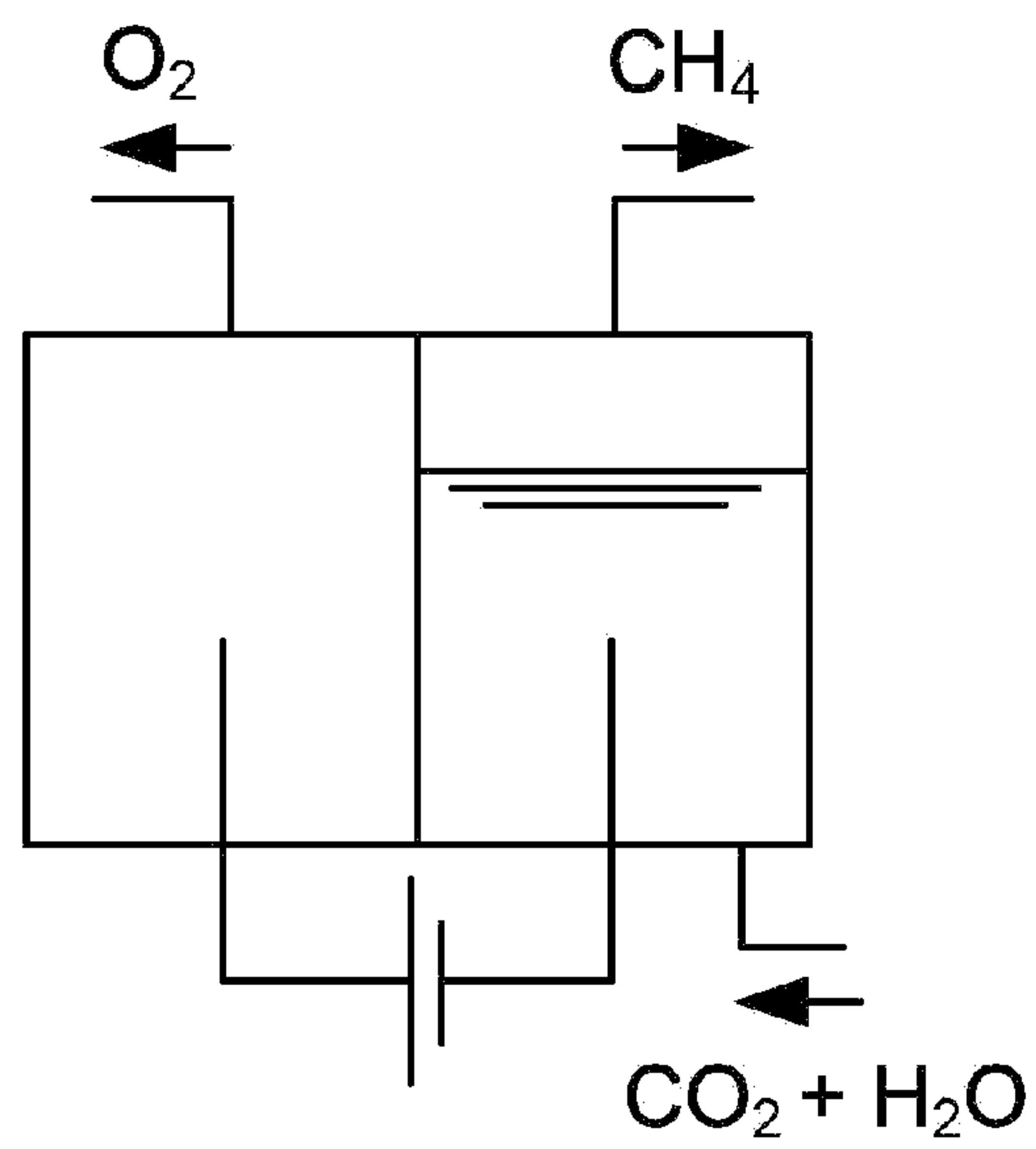


FIG. 2

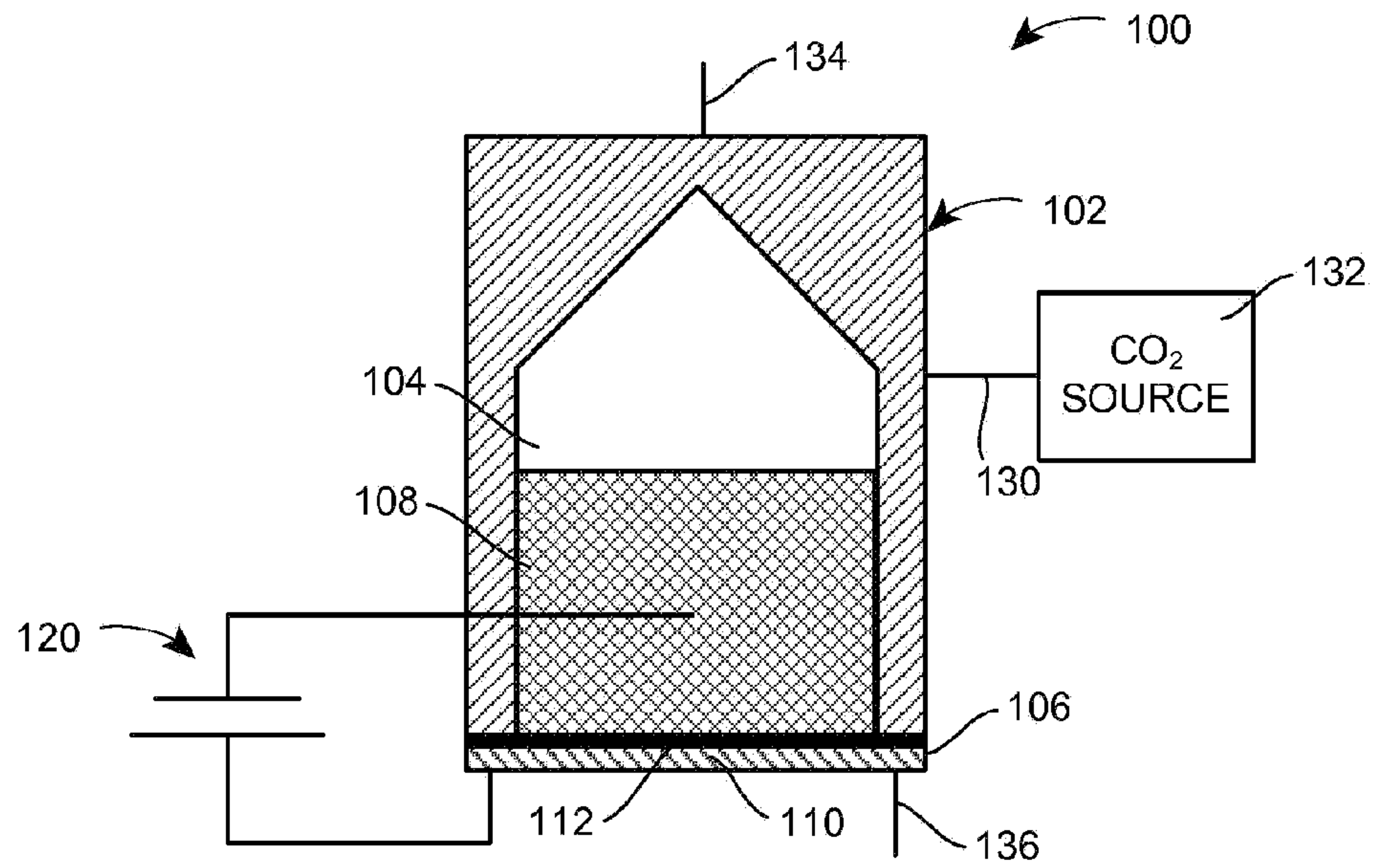


FIG. 3

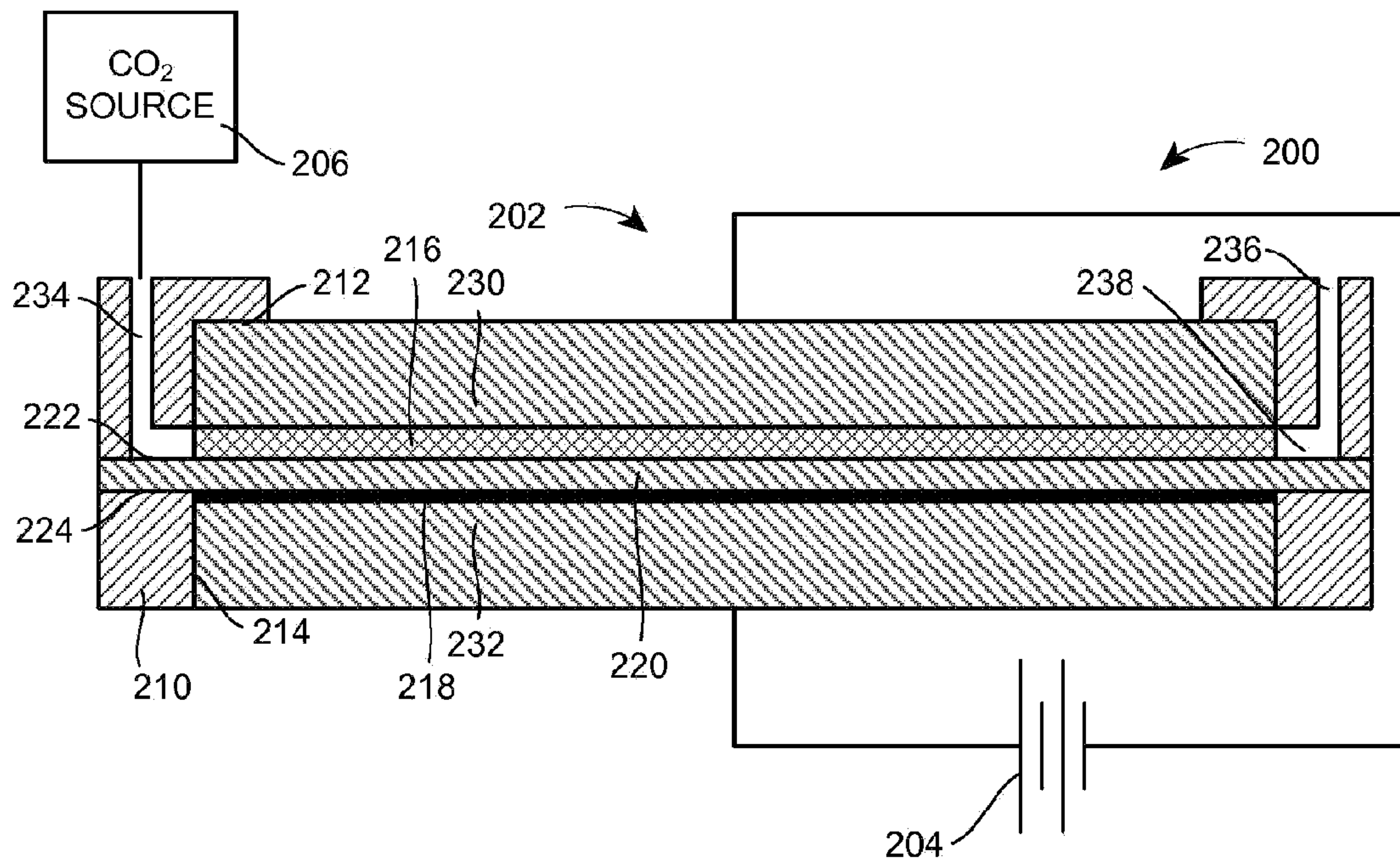


FIG. 4

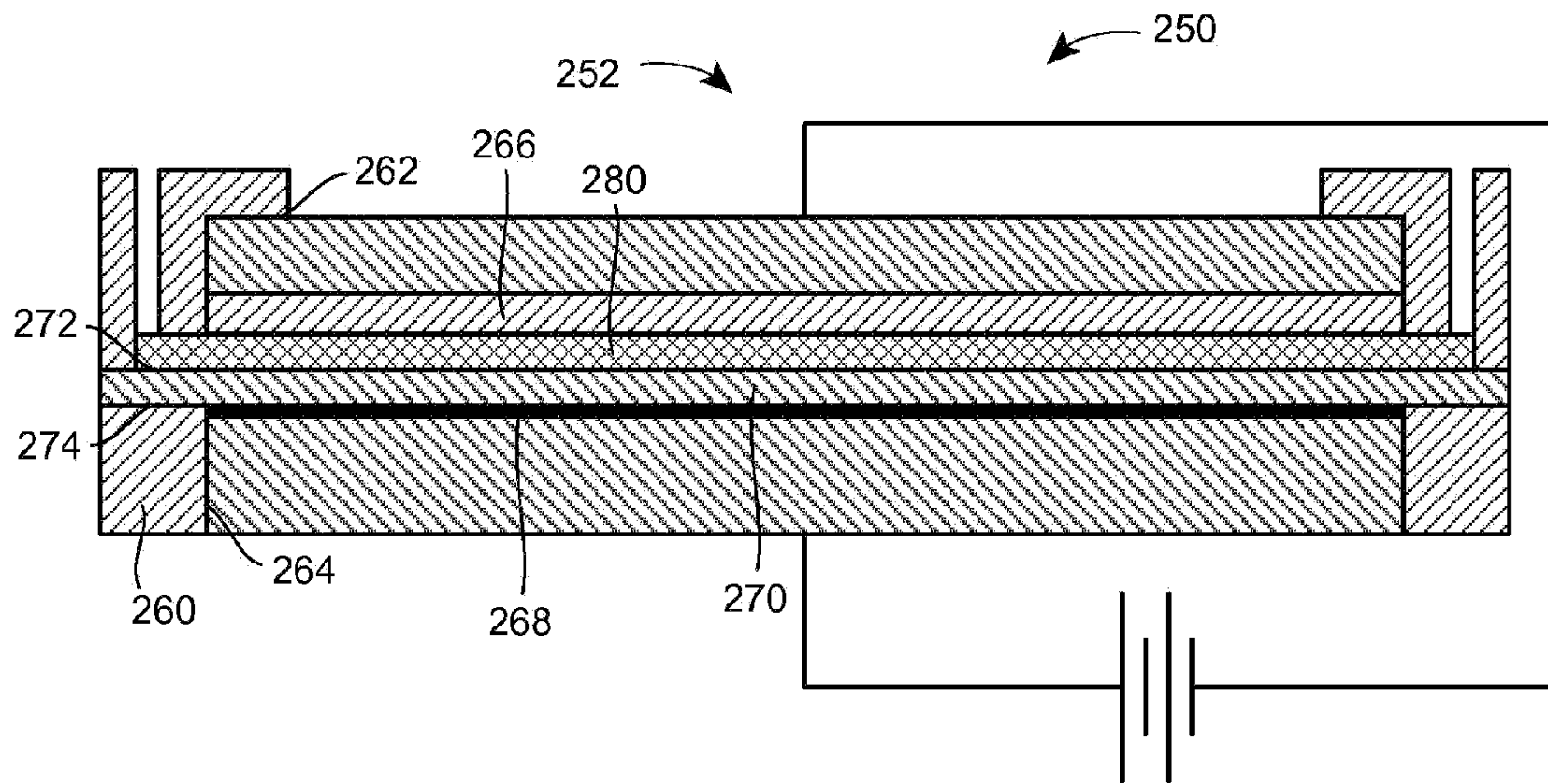


FIG. 5

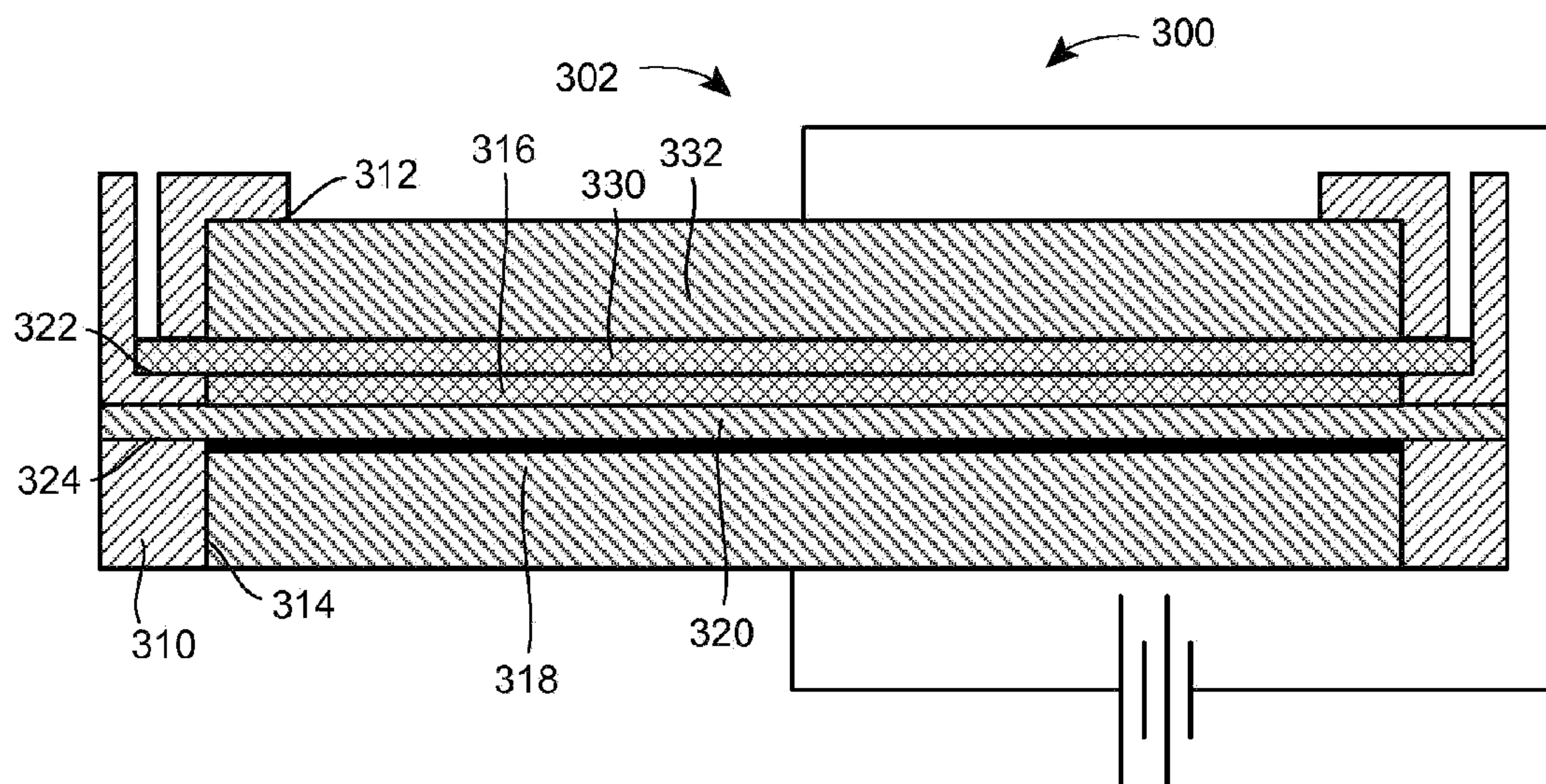


FIG. 6

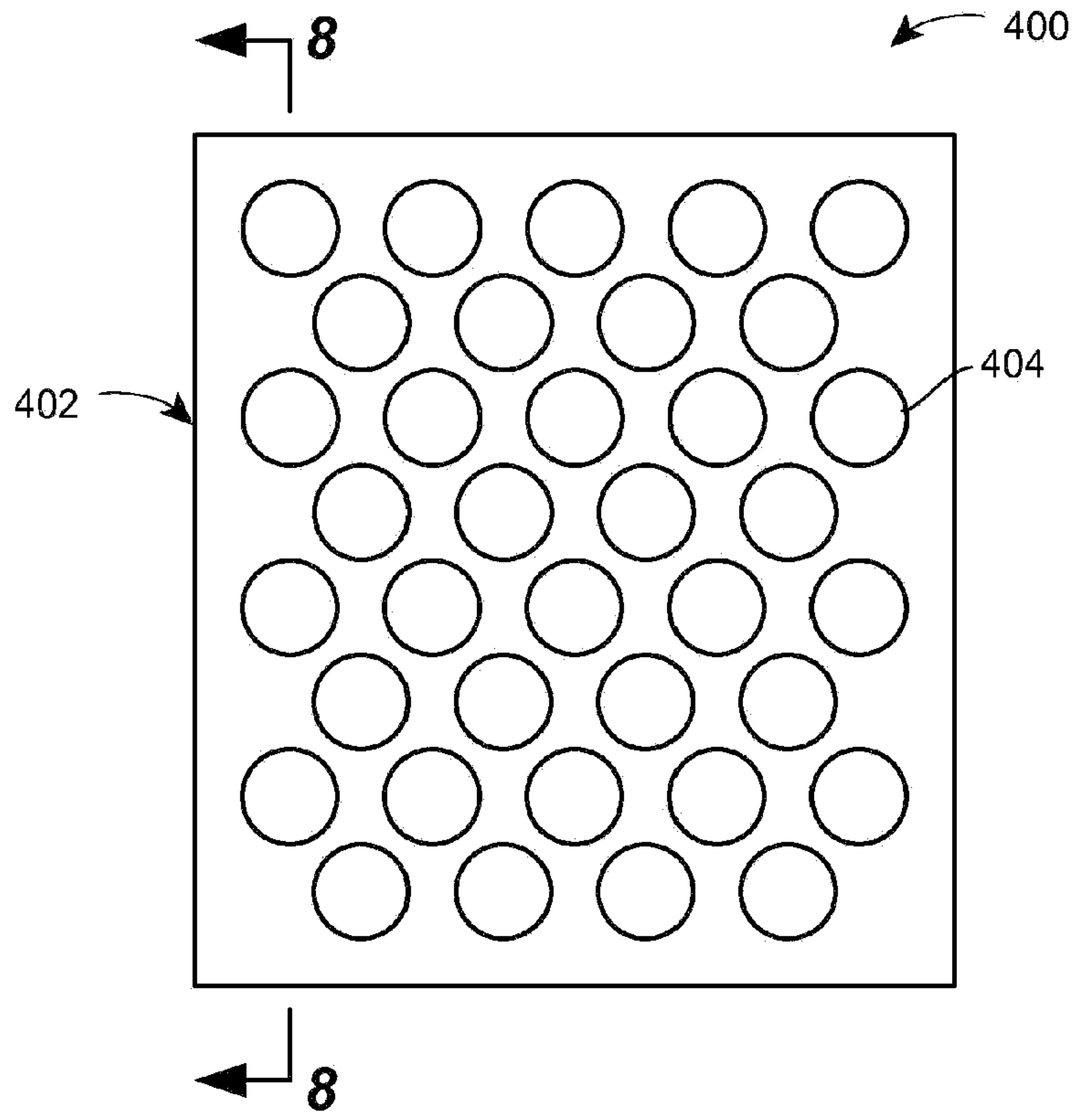


FIG. 7

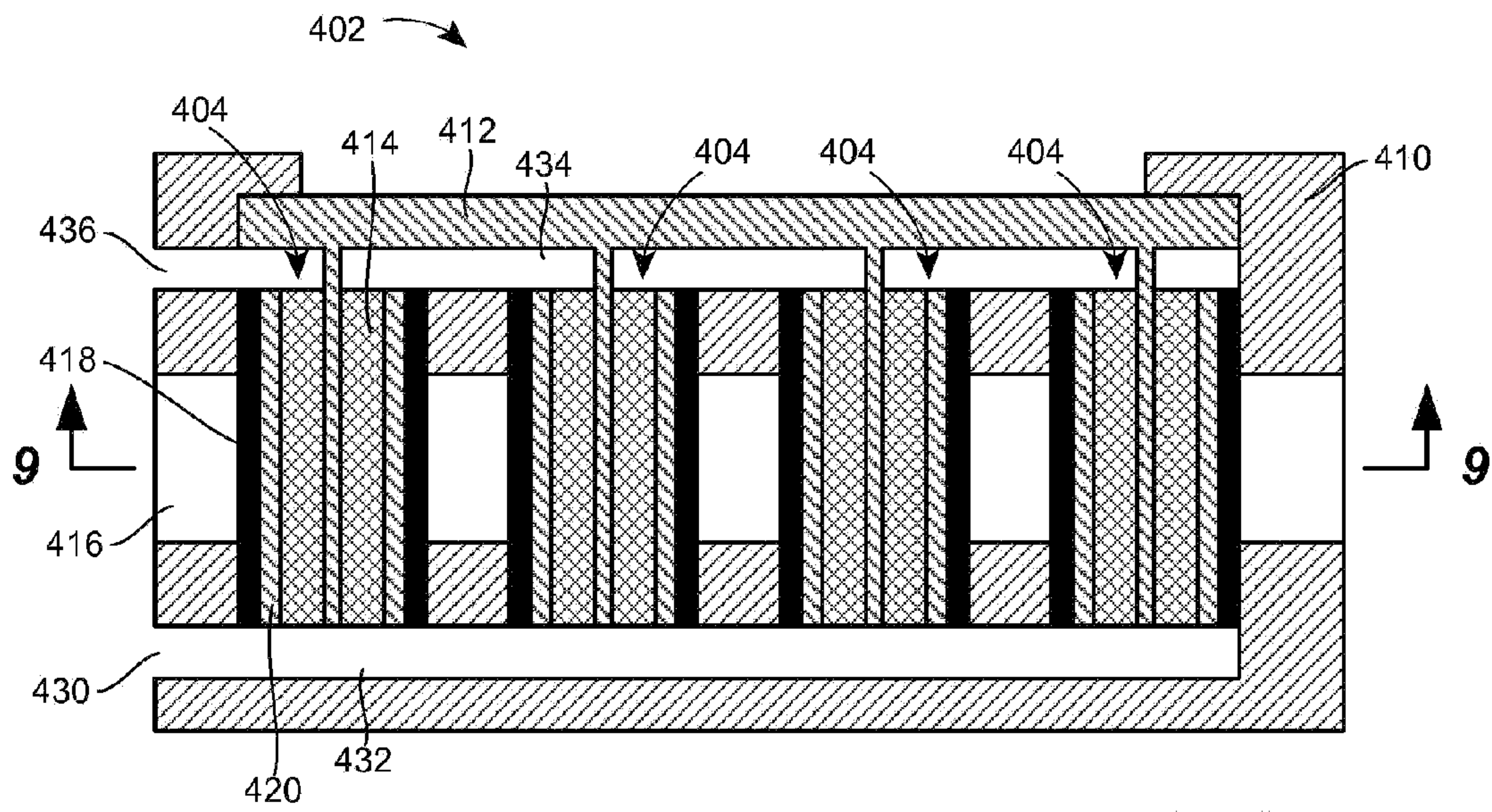


FIG. 8

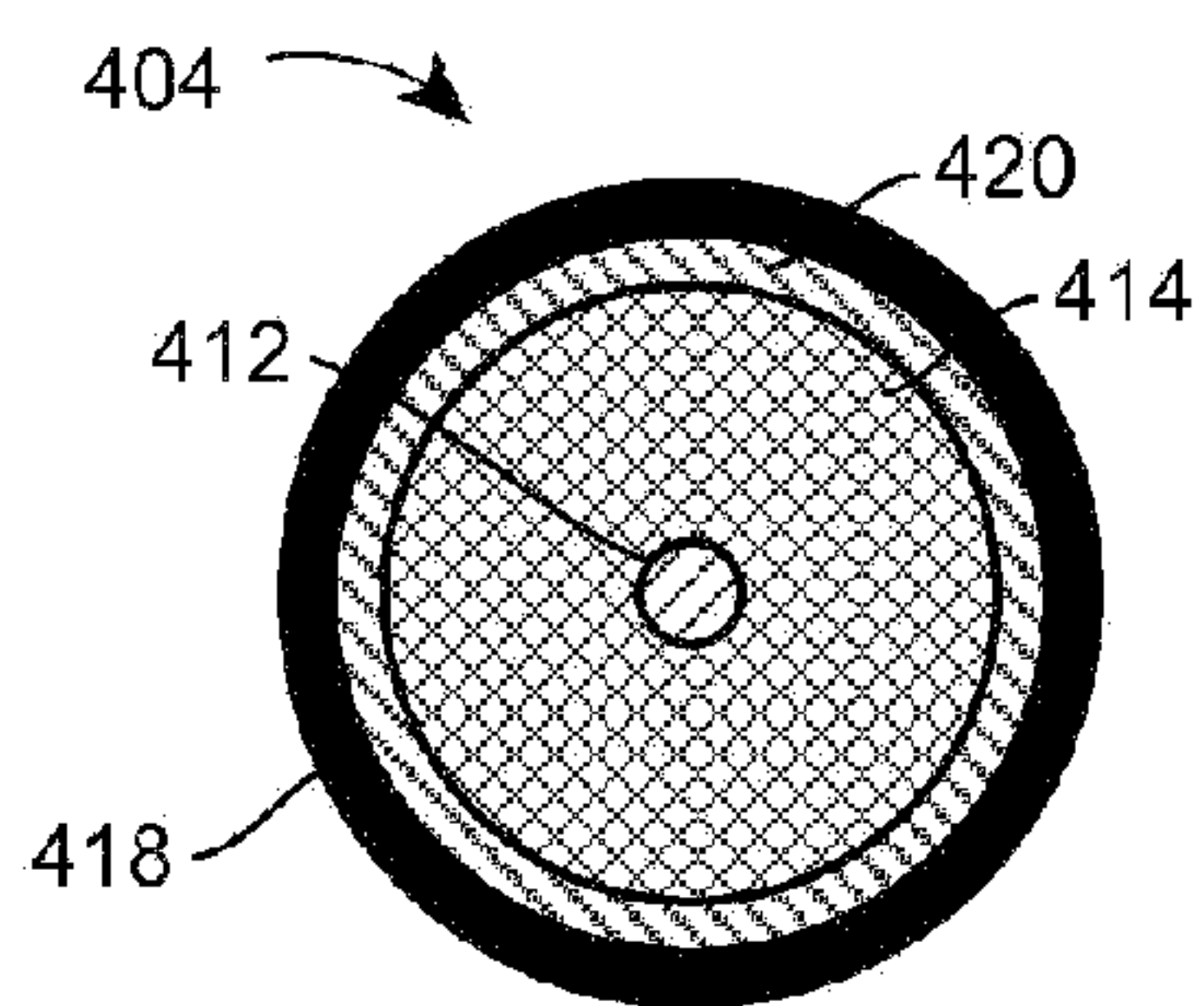


FIG. 9

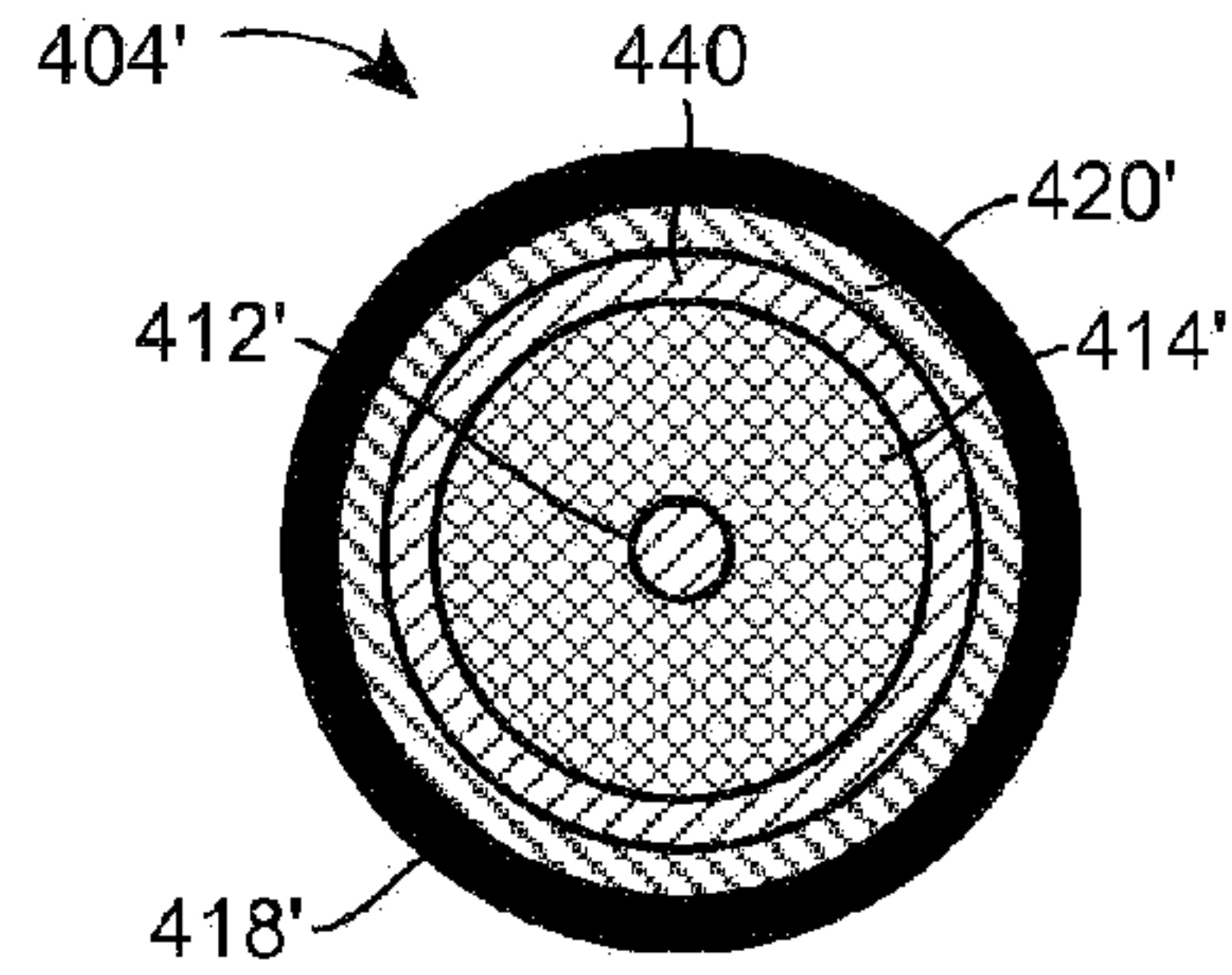


FIG. 10

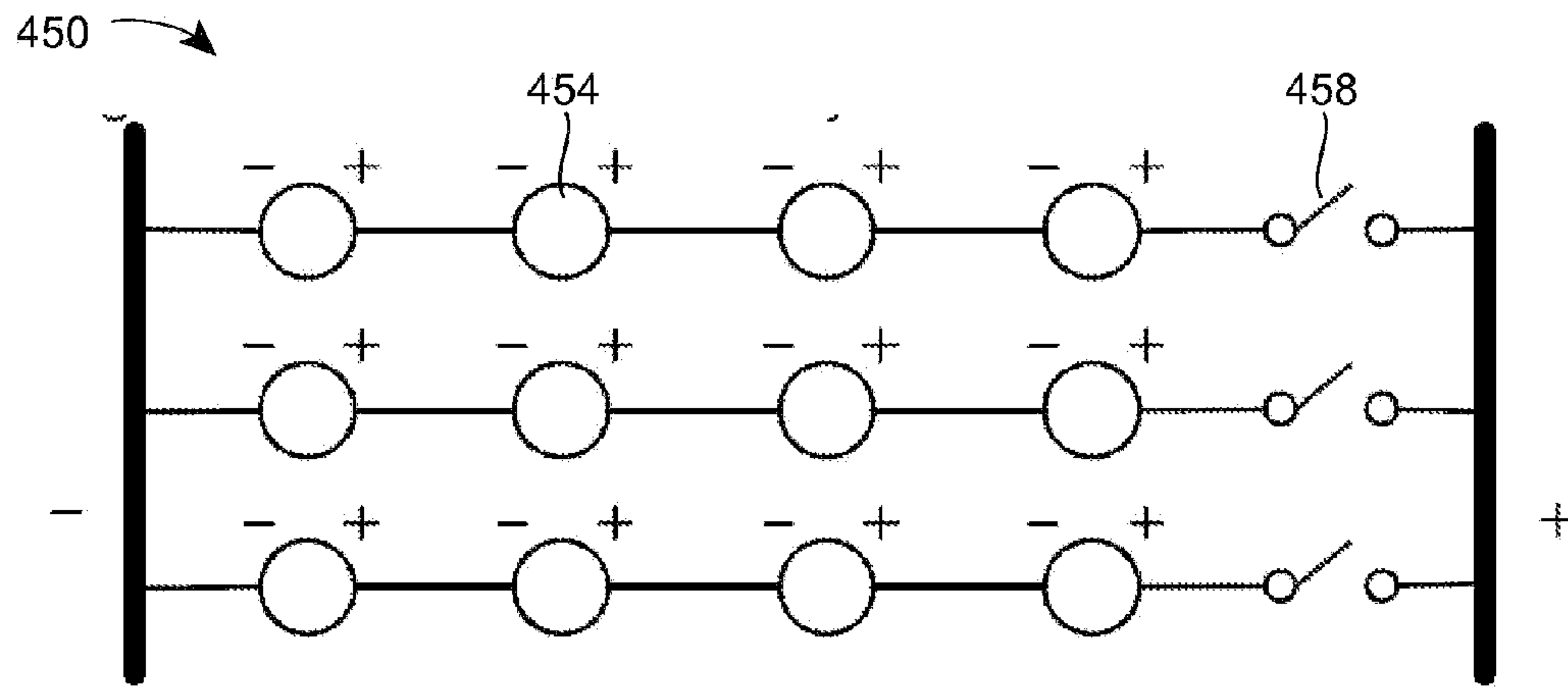


FIG. 11

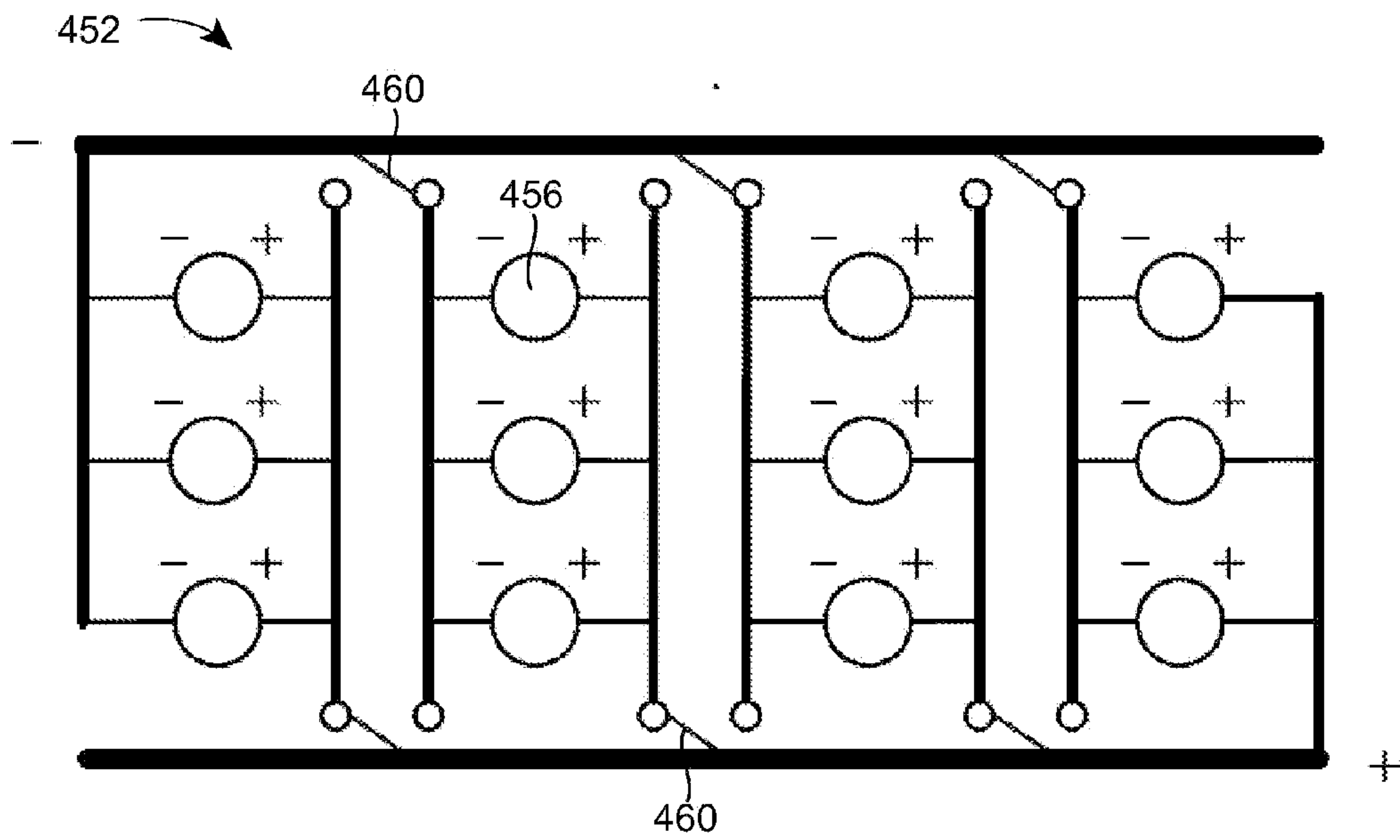


FIG. 12

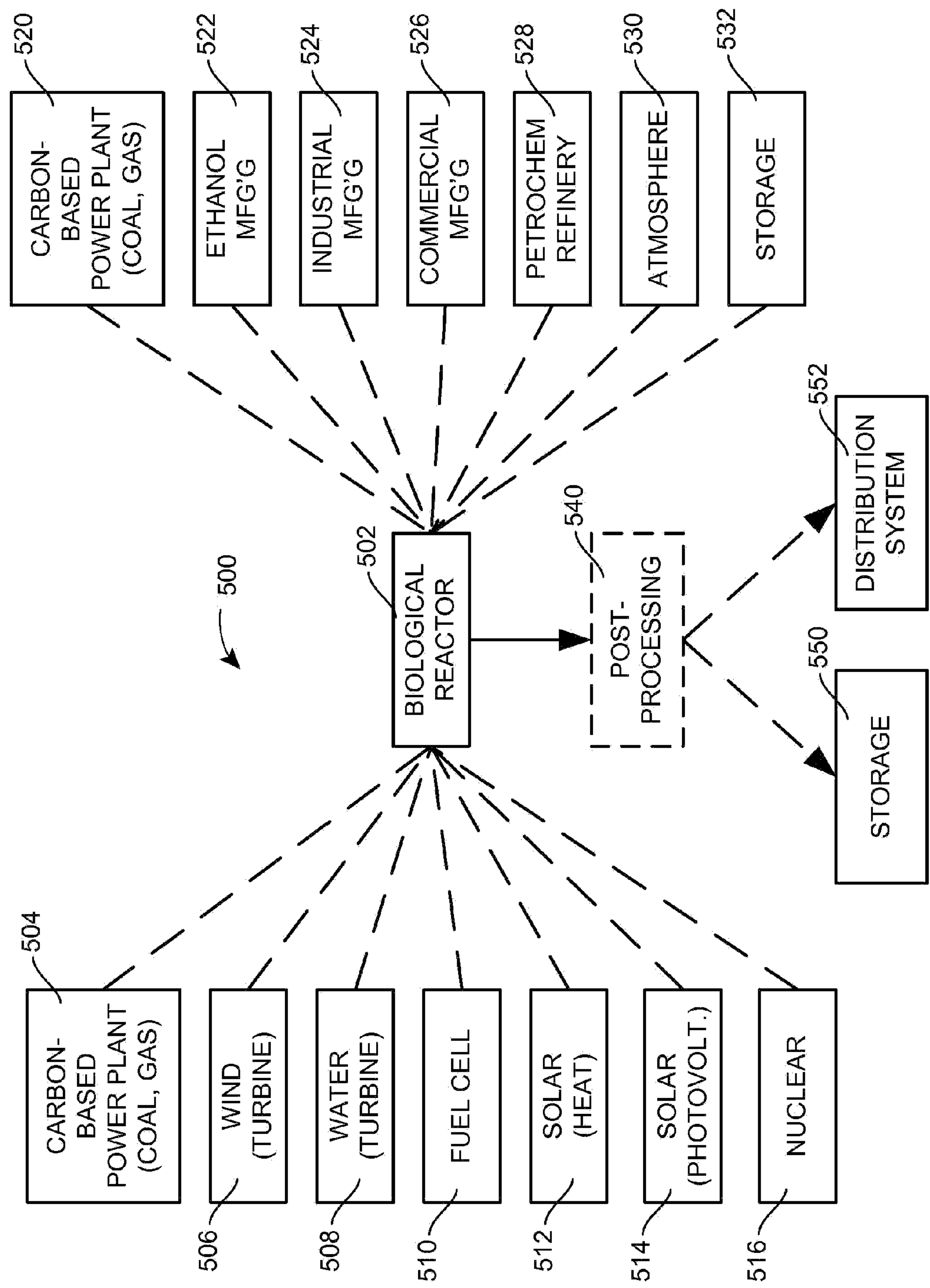
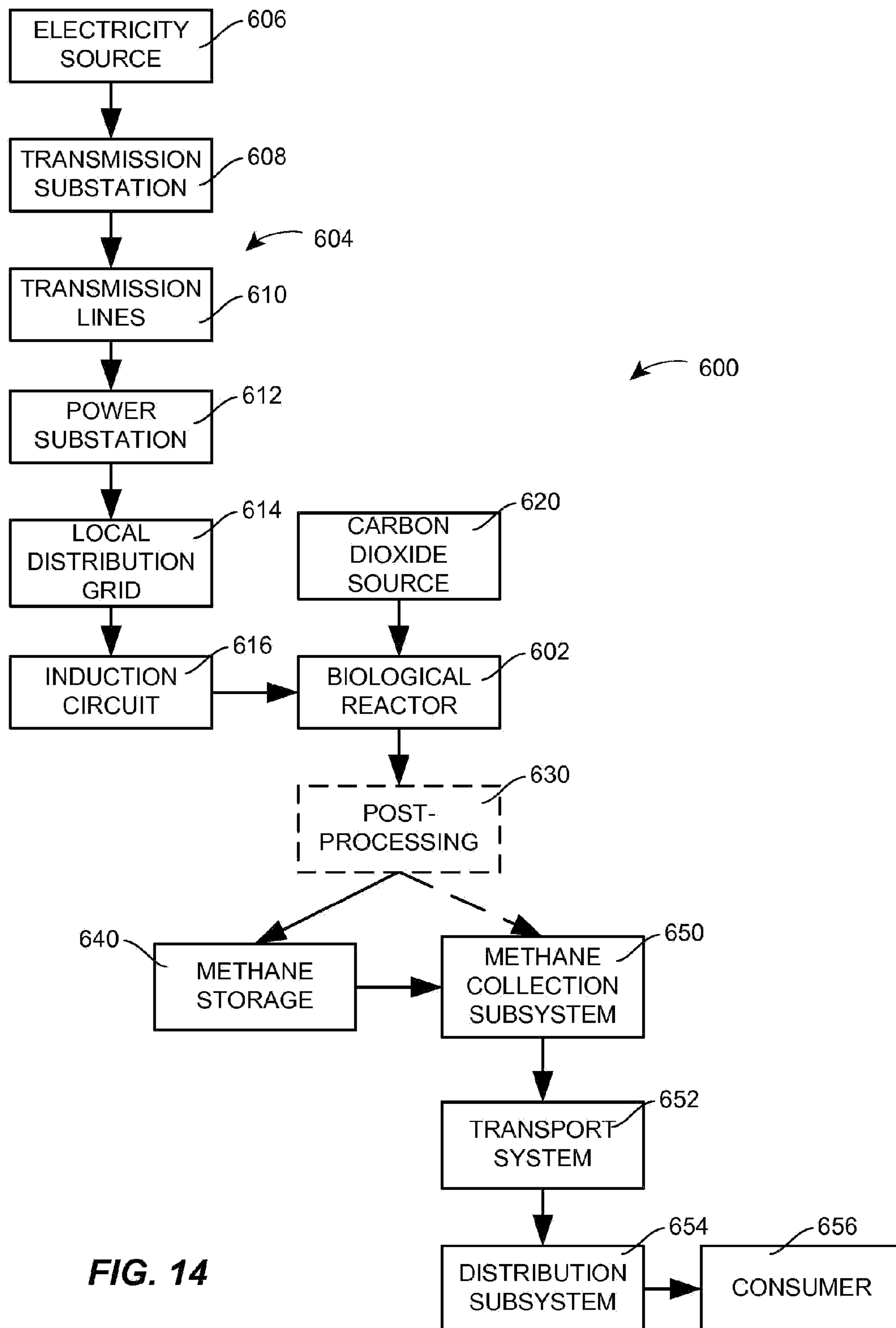
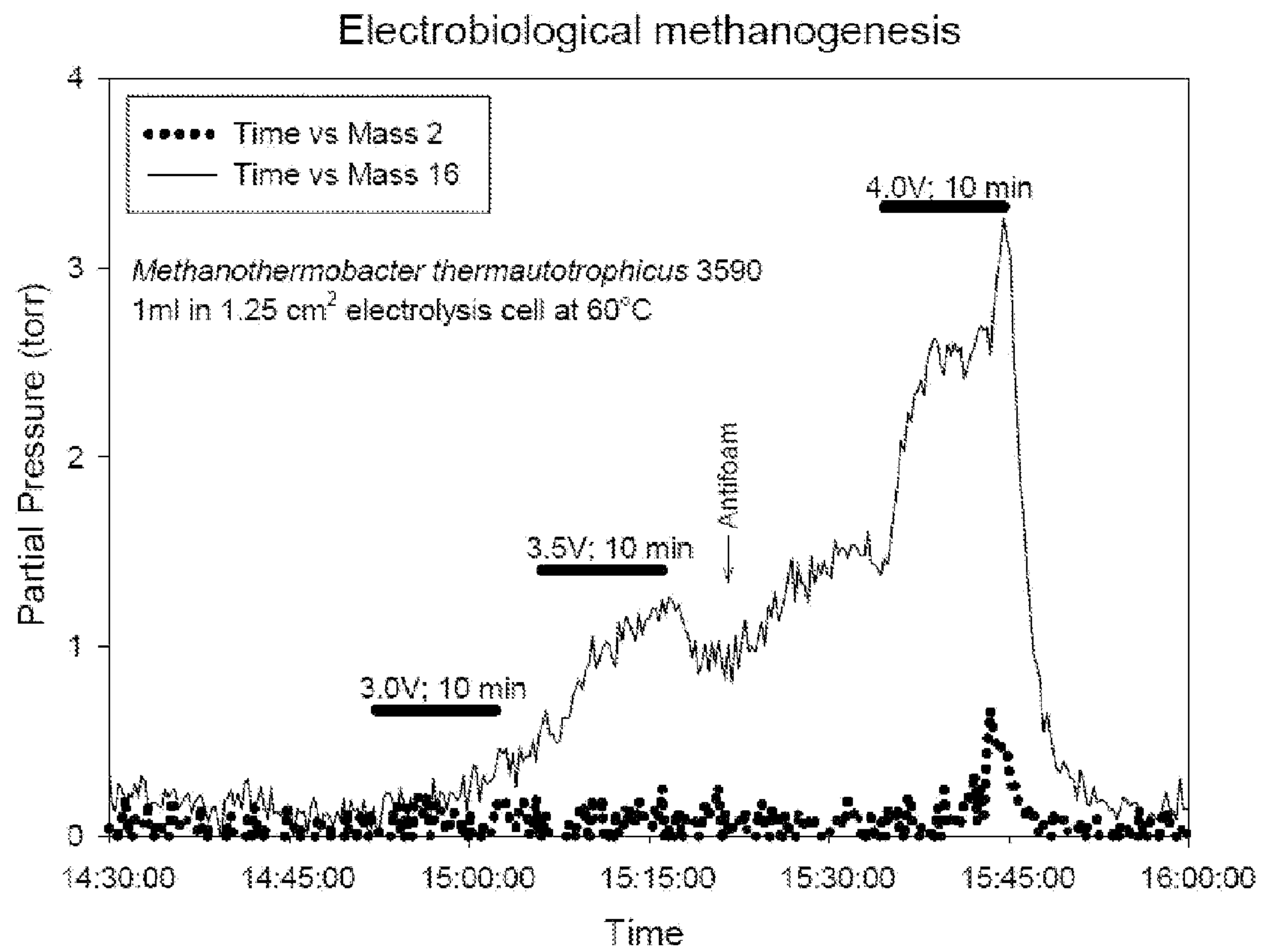


FIG. 13

**FIG. 14**

**FIG. 15**