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(71) Applicant *(for all designated States except US)*: **STICHTING WETSUS CENTRE OF EXCELLENCE FOR SUSTAINABLE WATER TECHNOLOGY** [NL/NL]; Agora 1, NL-8934 CJ Leeuwarden (NL).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **MAYER, Mateo, Jozef, Jacques** [NL/NL]; Breestraat 22, NL-3811 BJ Amersfoort (NL).

(74) Agents: **VERDIJCK, Gerardus, Johannes, Cornelis** et al.; Arnold + Siedsma, Sweelinckplein 1, NL-2517 GK The Hague (NL).

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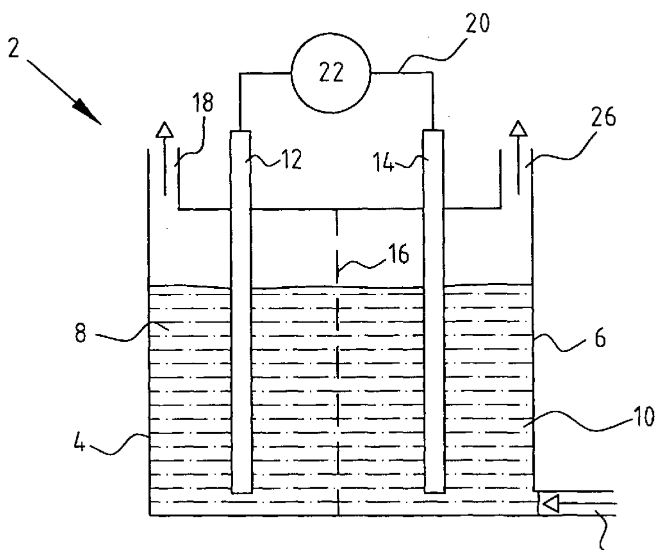

FIG. 1

(57) Abstract: The invention relates to a sensor for measuring effects of vibrations and/or fields on a micro-organism, comprising: - an anolyte space for containing a micro-organism and an anolyte; - an anode placed in the anolyte space for receiving electrons originating from the micro-organism; - a catholyte space; and - a cathode placed in the catholyte space, wherein the anode and the cathode are operatively connected such that a current and/or current difference is measurable as a result of an applied vibration or an electric and/or magnetic field.

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Sensor, bioreactor, microbial fuel cell and method for measuring and utilizing effects of vibrations and/or fields on a micro-organism in order to influence a micro-organism

The present invention relates to a sensor for measuring effects of vibrations and/or fields on a micro-organism. Such vibrations are for instance acoustic vibrations. The fields are electrical, magnetic or electromagnetic fields. These are understood to mean, among others, light and radio waves. By measuring the effect of vibrations and/or fields on a micro-organism it is possible to study particularly the influence of such vibrations and fields on biological systems in general and to quantify this influence reproducibly.

Present research into the influence of electromagnetic waves in general, and radio waves in particular, require high investment and are labour-intensive due to the expensive analysis equipment necessary for the purpose of the research. In addition, a large number of experiments have to be carried out before any conclusion can be drawn from the research. Among other equipment, microbiological laboratory facilities, professional microscope techniques and analysis equipment for determining the type and number of living cells are necessary for studying the influence of radio waves on the metabolism of micro-organisms.

The present invention has for its object to provide a relatively simple system or sensor for studying the influence of vibrations and/or fields on biological systems.

This object is achieved with the sensor according to the invention for measuring effects of vibrations and/or fields on a micro-organism, comprising:

- an anolyte space for containing a micro-organism and an anolyte;

- an anode placed in the anolyte space for receiving electrons originating from the micro-organism;
- a catholyte space; and
- a cathode placed in the catholyte space,

wherein the anode and the cathode are operatively connected such that a current and/or current difference is measurable as a result of an applied vibration or an electric and/or magnetic field.

Vibrations, including electromagnetic waves, can influence the functioning of biological systems. In addition to a direct influence as a result of a temperature increase due to dissipation of electromagnetic waves in water and/or organic substances and/or cells of living organisms, indirect influences of electromagnetic waves on living organisms are also detected. This is possible by measuring a current or current difference with an ammeter placed in the circuit with which the anode and the cathode are operatively connected to each other. Experiments have shown that, in addition to the power and the frequency of the carrier wave of electromagnetic waves, the presence and nature of modulation of these electromagnetic waves also have a considerable influence on biological systems. Amplitude modulation, phase modulation, frequency modulation and single sideband modulation can be envisaged as forms of modulation, although without limiting the present invention thereto. One hypothesis is for instance that the electromagnetic waves produced by mobile telephones have a measurable influence on the brain activity of humans. Following on from this, the hypothesis is known that, under determined conditions, mobile telephones have a measurable influence on the metabolism and cell division of micro-organisms.

The sensor according to the present invention is based on a microbial fuel cell and a microbial electrolyte cell. It is possible herewith to study the influence of electromagnetic and other radiation on biological systems in general, and living micro-organisms in particular, quickly and with low investment and labour costs. In a number of cases analysis of biological systems according to the present invention can replace the present research methods. In other cases the sensor and research method according to the present invention are highly suitable for performing a first screening for the purpose of further definition of follow-up research.

A micro-organism is introduced into the anolyte in the anolyte space of the sensor according to the invention. This anolyte space or anode compartment is preferably operated under oxygen-free or low-oxygen conditions. The anolyte preferably comprises nutrients which serve as nutrition for the micro-organisms in this space. The micro-organisms present in the anolyte have the property of being able to relinquish electrons to the anode in this compartment as a by-product of their metabolism. The micro-organisms can transfer the produced electrons directly to the anode through adsorption of the micro-organisms to the surface of the anode. In addition to catholyte, a cathode is placed in the catholyte space or cathode compartment. The anode and the cathode are operatively connected such that a current and/or current difference is measurable as a result of a vibration or a field. Oxygen is preferably reduced to water in the cathode compartment using the electrons and protons. Other reactions are however also possible. Such vibrations and/or fields influence the action of the micro-organisms, which will result in a change in the quantity of electrons generated per unit time.

Experiments with a sensor according to the invention have shown that, if such a sensor is operated under stationary process conditions and consequently produces a constant current, such a sensor is highly suitable for studying the influence of vibrations on biological systems. The vibrations can consist of acoustic vibrations or electromagnetic waves, including light and radio waves. If a microbial fuel cell is exposed to radio waves during stationary operation, for instance by placing the fuel cell in the vicinity of an antenna of an operative transmitter, and the radio waves influence the metabolism of the micro-organisms directly or indirectly, this can then be detected due to a decrease or increase in the current produced by the microbial fuel cell. In this way it is possible to study quickly and effectively the influence of a range of different types of vibration on the functioning of biological systems. It is noted that the measurement of the current produced by the microbial fuel cell can be disrupted by the proximity of a strong radio signal. For this reason it can be important to compare the current in the stationary state without radio signal to the current measured after exposure of the cell to the radio signal in question. It will be apparent to the skilled person that the measuring system can also be adapted in relatively simple manner such that the radio waves do not influence the measurement, for instance by making use of a Faraday cage.

In an advantageous embodiment according to the present invention the anolyte space comprises a mediator for receiving the electrons from the micro-organism and relinquishing them to the anode.

Through the use of a so-called mediator in the form of a chemical, usually organic, component, electrons produced by the micro-organism can be received and then relinquished to the anode. Adsorption of the micro-organisms to the surface of the anode is hereby not necessary in order to obtain a good operation of the sensor.

In an advantageous preferred embodiment according to the present invention the sensor makes use of a redox couple.

Although it is possible to reduce oxygen to water with electrons and protons in the cathode compartment, it is also possible to make use of other counter-reactions of the anode reaction in the anode compartment. Use can be made for this purpose of a suitable redox couple. A preferably employed redox couple is the ferricyanide/ferrocyanide couple.

For a microbial fuel cell on production scale it is desirable to have the oxygen reaction as counter-reaction, since the redox couple would otherwise have to be regenerated from time to time. It can be acceptable to apply a redox couple for a microbial fuel cell applied as a sensor. However, the reduction step of oxygen has the advantage that it is not necessary to apply special chemicals such as ferricyanide.

In a further advantageous preferred embodiment according to the present invention the cathode comprises a biocathode.

Due to the provision of a biocathode bacteria receive electrons from the electrode. It is possible to use aerobic biocathodes wherein a mediator, for instance iron, is reduced by the cathode and subsequently re-oxidized by the bacteria. It is also possible to use anaerobic biocathodes, which receive the electrons directly. It is not necessary here to use a mediator and for instance hydrogen. It is thus possible, among other things, to convert nitrate into nitrogen using a biocathode. Usable bacteria are, among others, geobacter and pseudomonas fluorescens.

In an advantageous preferred embodiment according to the present invention circulation means are provided for circulating anolyte through a separate space.

By applying a circulation of the anolyte through a separate cell, where the anolyte is exposed to vibrations or to a stirred system, the process of treating the anolyte and an electron donation in the anolyte space can be separated.

In an advantageous preferred embodiment according to the present invention the micro-organism comprises yeast, such as bakers' yeast.

Experiments have shown that bakers' yeast, or other type of yeast, can be applied as micro-organism in the anode space. In the metabolic cycle of bakers' yeast and/or the nutrition for bakers' yeast it has been found in practice that sufficient mediator is present to ensure a good electron transfer to the anode without it being necessary for large quantities of bakers' yeast to be adhered to the anode surface.

In a further advantageous preferred embodiment according to the present invention the anolyte comprises diluted juice concentrate, such as apple juice.

Experiments have shown that fruit juice, such as apple juice, in the form of commercially available diluted juice concentrate, can be applied in effective manner as anolyte. The apple juice has the advantage that it has a buffering action and that saccharides, partially oxidized saccharides and the (poly)carboxyl acids present in the apple juice have a complexing action on polyvalent metal ions, including iron. Another advantage resulting from the use of bakers' yeast is that the relatively large quantity of carbon dioxide which is formed in the fermentation process, and which leaves the anolyte in the form of gas bubbles, ensures continuous extraction of oxygen from the anolyte. The oxygen content in the anolyte hereby remains very low without it being necessary to close off the anolyte space from the ambient air by means of a water seal. This is relevant since the construction and setting into operation of the sensor hereby become considerably simpler. An additional effect of applying a sensor with anolyte that is not closed off from the ambient air is that a decrease in the biological activity of the yeast cells results in a lower carbon dioxide production rate, and thereby to a higher concentration of oxygen in the anolyte. This is caused in that the extraction speed of oxygen decreases in water. Owing to this higher concentration of oxygen in the anolyte less current is produced, which enhances the operation of the sensor. In the case that the secondary effect is undesirable in the intended study, use can of course be made of a water seal in order to limit to a minimum transfer of oxygen from the environment to the anolyte.

In a preferred embodiment according to the present invention a membrane is provided as separation between the anolyte space and the catholyte space.

By separating the anolyte space and the catholyte space by means of a membrane, in particular a cation-selective membrane, the protons produced in the anode compartment can diffuse through this cation-selective membrane to the cathode space. The protons are reduced in the cathode space.

In an alternative preferred embodiment according to the present invention an absorbing element is provided between the anolyte space and the cathode.

By providing an absorbing element between the anolyte space and the cathode it is possible to dispense with the cation-selective membrane. This is advantageous since such a membrane can become damaged, become soiled and may degenerate slowly. Using an absorbing element it is possible to obtain a more robust sensor with a longer lifespan, without maintenance or cleaning being necessary. In the sensor with the absorbing element bakers' yeast and the nutrition therefor are for instance situated in the anolyte space. As a result of the carbon dioxide production the solution becomes substantially oxygen-free. An anode of active carbon is preferably situated in the anolyte space. By suspending the absorbing element partially in the anolyte and attaching the cathode to the absorbing element at the other end thereof, the absorbing element will be filled with anolyte, for instance through capillary action. Owing to the contact of the absorbing element with the environment, such as ambient air, the anolyte in the absorbing element, and thereby on the cathode, will become saturated with oxygen. An oxygen-free or low-oxygen anolyte is thus obtained, as well as an oxygen-rich catholyte. The catholyte space is in fact formed by the part of the absorbing element that is not placed in the anolyte with the cathode and the direct vicinity thereof. In an advantageous preferred embodiment the absorbing element is formed by a cotton cloth. An additional advantage of such a sensor with absorbing element is that the transfer of the components takes place by means of diffusion and/or convection. It is hereby possible to realize a larger quantity of ions and other components between the anolyte space and the cathode in simpler manner compared to a sensor with a membrane. A further additional advantage of such a sensor is that such a sensor is relatively simple, wherein it is possible to use only so-called "foodgrade" chemicals together with standard graphite electrodes and for instance cotton.

By providing the absorbing element, or at least that part not placed in the anolyte, with anolyte continuously or periodically, for instance by means of spraying, sufficient exchange of the ions between anolyte and catholyte can take place in relatively simple manner. This is possible since the volume of the catholyte is preferably considerably smaller than the volume of the anolyte. Through this mixing of "depleted" catholyte with the larger volume of anolyte the properties or composition of the anolyte hardly change, and the action or activity of the sensor will not be adversely affected thereby. Such a spraying or moistening can be realized by, among others, diffusion, the use of pumps or sprayers, wind and flow profiles already present in a space as a result of already present stirring systems.

A problem which could occur in such a sensor is that a significant amount of charged mediator from the anolyte gets onto the cathode surface through substance transport via the cloth. It will be apparent to the skilled person that this process would adversely affect the operation of the sensor since the mediator could then relinquish electrons to the cathode and thereby reduce the effective output of the microbial fuel cell. Surprisingly however, experiments have shown that the problem of the electron transfer by the mediator via the cloth to the cathode is prevented to a sufficient extent. A hypothesis put forward by the inventor of the present invention relating to the absence of adverse effects of mediator getting onto the cathode due to substance transport through the cloth is that, if the mediator gets into the cloth through diffusion or through wetting of the cloth with anolyte, this mediator will be in intensive contact with oxygen. A redox reaction with oxygen takes place as a result, whereby the mediator is no longer charged. Since the discharged mediator can no longer transfer electrons, it no longer has any adverse effect on the operation of the microbial fuel cell as soon as this mediator reaches the cathode.

The effectiveness with which electricity can be produced with the present invention depends to a significant extent on a good design of the cloth between catholyte and anolyte. Important parameters for obtaining a great electric power per square metre of applied cloth are: the thickness of the cloth, the capillary action of the cloth, i.e. the microstructure in the cloth, the intensity of the contact between the cathode and the cloth expressed in square metres of cathode surface per square metre of cloth, the distance between anolyte and cathode expressed in metres of cloth, the manner in which the cloth is aerated, use of a suitable mediator and the speed of replenishment of the catholyte with anolyte. In a preferred embodiment of the present invention the cathode arranged on the cloth does not make direct contact with the anolyte, since experiments have shown that in a number of cases, although not all such cases, the electric power of the sensor is lower. The sensor operates here as a type of microbial fuel cell. In another preferred embodiment the cloth or a part of the cloth is impregnated with a conductive material, such as active carbon or a metal. The cloth, or a part of the cloth, can also consist wholly of a conductive material and the wetting is realized in part owing to the capillary action of the conductor. An additional advantage of this sensor is that it is relatively easy to operate the catholyte under different process conditions than the anolyte. This can for instance be realized by varying the degree of replenishment of the catholyte by bringing the cloth into contact with a small quantity of gas, such as carbon dioxide, or with a small quantity of base or acid. In the case of this production the variable costs remain low since the overall volume of the catholyte is very small. For this reason also the composition of the anolyte hardly changes after mixing of catholyte and anolyte.

The invention also relates to a bioreactor for producing and/or selecting a micro-organism, comprising:

- a reactor vessel for containing a micro-organism;
- means for applying vibrations such as acoustic vibrations and/or an electric, magnetic or

electromagnetic field in order to influence the micro-organism.

The same effects and advantages as those described for the sensor apply to such a fuel cell. Using the bioreactor it is possible to screen, and optionally simultaneously detect, cultures of micro-organisms.

If a mixture of micro-organisms is introduced into for instance a microbial fuel cell according to the present invention, a stationary state resulting in a determined current production will be reached, given the process conditions. By now exposing the anolyte to vibrations, such as acoustic vibrations, light and radio waves, an alternating electric field or a magnetic field, the metabolism of the various micro-organisms will be influenced, whereby some micro-organisms will increase in number. Due to the changed conditions in the anolyte a different current will in most cases also begin to flow. It is thus possible to realize in situ selection of cultures by means of the present invention, and in this way optimize the operation of a microbial fuel cell. A microbial fuel cell can hereby be set so as to ensure that the desired micro-organisms are active and the growth of undesirable micro-organisms is inhibited. If desired, these undesirable micro-organisms can be inhibited, or these undesirable micro-organisms can even be destroyed. With the present invention it is possible to obtain a stationary state in a microbial fuel cell which would not occur without exposure to vibrations under given process conditions. After this stationary state has been reached, the vibration source can in a number of cases be switched off since the undesirable micro-organisms have been removed from the system. In other cases it is desirable not to switch off the vibration source.

The invention also relates to a microbial fuel cell, comprising:

- an anolyte space for containing a micro-organism and an anolyte;

- an anode placed in the anolyte space for receiving electrons originating from the micro-organism;
- a cathode; and
- an absorbing element placed between the anolyte space and the cathode.

Such a microbial fuel cell has the same advantages and effects as described above for the sensor and the bioreactor.

The invention further relates to a method for influencing a micro-organism, comprising the steps of:

- providing the micro-organism in an anolyte space;
- placing an anode in the anolyte space;
- providing a cathode operatively connected to the anode such that a voltage occurs between the anode and the cathode; and
- exposing a micro-organism to vibrations, such as acoustic vibrations, an electric field and/or a magnetic field.

The same effects and advantages as described for the sensor, bioreactor and microbial fuel cell can be achieved with such a method.

Further advantages, features and details of the invention are elucidated on the basis of the preferred embodiments thereof, wherein reference is made to the accompanying drawings, in which:

Figure 1 is a schematic representation of the operation of the principle according to the invention; and

Figure 2 shows an alternative preferred embodiment according to the invention.

In a first embodiment 2 (Figure 1) two compartments or electrode spaces 4, 6 are provided. Compartment 4 is the anode compartment in which anolyte 8 is provided. Catholyte 10 is provided in cathode compartment 6. An anode 12 is arranged in anode compartment 4 and cathode compartment 6 is provided with a cathode 14. A cation-selective membrane 16 is arranged between the two compartments 4, 6. A micro-organism in the form of bakers' yeast is arranged in anolyte 8. The anolyte is a fruit juice in the form of juice concentrate. Produced in anolyte space 4 is carbon dioxide which is discharged from the space via outlet 18. Electrodes 12, 14 are operatively connected via circuit 20. Circuit 20 comprises an ammeter 22 with which current, and particularly changes therein, can be measured. The protons diffused by membrane 16 are reduced in cathode space 6 using oxygen, this producing water. Oxygen is supplied via inlet 24 and the reaction products can be discharged via outlet 26 of cathode compartment 6.

In an alternative embodiment of sensor 28 (figure 2) anolyte 32 is introduced into an anode space 30. An anode 34 is arranged in anode space 30. A first outer end 38 of an absorbing element 36 in the form of a cotton cloth is also suspended in anolyte 32. A cathode 40 is enclosed by the other cloth outer end 42. Anode 34 and cathode 40 are connected via circuit 44, in which an ammeter 46 is provided.

Possible applications of the new sensor 2, 28 are elucidated below. If a biological system in the anolyte space of a fuel cell is exposed to the influence of for instance electromagnetic waves, it is then possible that the anolyte heats up through energy dissipation of the waves in water and/or in the biological system. This heating has consequences for the metabolism and/or division of the micro-organisms and/or chemical reactions and/or enzymatic reactions in the anolyte, whereby it is highly likely that the current produced by the sensor in the form of a microbial fuel cell also changes. A microbial fuel cell in which a temperature measurement is possible forms part of the present invention. If however the power of the radio waves is limited, and consequently the increase in the temperature of the anolyte can hardly be detected, electromagnetic waves can still have a significant influence on the biological system, and therefore also on the current produced by the microbial fuel cell. One of the underlying mechanisms here is that the cell membranes of cells of living organisms have an asymmetrical composition and that, as a function of the length coordinate perpendicularly of the cell membrane, ions have an asymmetrical mobility. Cell membranes can hereby function as radio wave demodulator, since from an electrotechnical perspective they can be viewed as a parallel circuit of a diode, a resistor and a capacitor. The consequence hereof is that, for instance in the case of an amplitude-modulated radio wave with a frequency of the carrier wave of 2 MHz and an amplitude modulation with a frequency of 100 kHz, an alternating voltage can occur over the membrane with a frequency of 100 kHz. Such an alternating voltage over the membrane can change the properties of the membrane or even cause electroporation followed by cell death. It will be apparent to the skilled person that the frequency and nature of the modulation at which radio waves have an effect on a living cell in general, or on the micro-organism in particular, depends on the nature of the living cell or the micro-organism. This means that it is possible to translate effects of radio waves on a micro-organism to effects on other living cells, assuming that the "electrical properties", particularly in terms of resonance frequency and demodulation characteristic of both the micro-organisms and other living cells, are known. It is thus possible in principle to translate effects measured with a sensor according to the present invention, wherein bakers' yeast is for instance applied in the anolyte, to possible biological effects on humans.

In several of the discussed possible applications the biological system employed serves as a model for another biological system. The micro-organisms can thus serve as model for, among others, humans. In a possible other application of such a bioreactor, the operation of a bioreactor is controlled by means of a sensor according to the present technology, for instance for the production of medicines. This is possible for instance by equipping a bioreactor with electrodes according to any of the concepts in the present invention. If the bioreactor is now exposed to vibrations, the sensor system will measure a different current under determined vibration conditions, this indicating that the processes in the bioreactor are being influenced. In this way the bioreactor can be optimally adjusted and, if necessary, the vibration source remains operational after adjustment of the optimum.

Yet another application of the present invention is a sensor for detecting biofouling, wherein a process liquid is added to the anolyte or catholyte of the sensor and wherein, depending on the nature and the amount of biofouling deposited on an electrode of the sensor, the current production of the sensor changes.

The sensor principles 2, 28 can also be used as microbial fuel cell. It is therefore also possible with the new technology to convert an anaerobic waste water treatment plant to a microbial fuel cell with very low investment. The variable costs and the maintenance of such a microbial fuel cell are further also low. If an anaerobic reactor is equipped with carbon mats, and cotton cloth incorporating carbon mats as cathode is tensioned perpendicularly of the liquid surface, we then have a microbial fuel cell. If desired, use can be made here of the moistening of the absorbing element in the case that sensor principle 28 is applied.

Experiment

5 litres of drinking water at a temperature of 25°C were added to a 10-litre plastic container with screw cap. 750 ml of concentrated apple juice (Dixap brand from Covelt, with a carbohydrate content of 87.5 gm carbohydrates per 100 ml and 0.1 gm protein per 100 ml) was then added. After intensive mixing, 21 gm instant yeast (3 bags of 7 grams, brand Dr. Oetker, equivalent to 75 grams of fresh yeast) was added. The mixture was then shaken intensively for 5 minutes, after which the liquid was stored for 3 hours in the presence of oxygen, i.e. the screw cap of the 10-litre container was not screwed onto the container. The thus obtained mixture was then shaken intensively. About 400 ml of the fermenting suspension was then placed in a 750 ml

beaker with a diameter of 10 cm. A graphite electrode, referred to below as the anode, with an effective area of $2*10^{-3}$ m^2 was arranged in the beaker. A cotton cloth was then suspended in the liquid, and about 10 cm above the liquid surface this cotton cloth was brought into intensive contact with a second graphite electrode, referred to below as the cathode, with an area of $1*10^{-3}$ m^2. Due to the capillary action this second electrode became moist and, due to the highly intensive contact with the air of the liquid in the cloth and on the cathode, this electrode acts as a cathode. The anode and cathode were connected to a voltmeter and after about 3 hours this voltmeter indicated a voltage of about 50 mV. A resistance of 10 kOhm was then applied between anode and cathode, and after about 10 minutes a stable voltage of about 15 mV was established between anode and cathode. The operation of the microbial fuel cell according to the present invention was hereby demonstrated. It is noted that the fuel cell in this example functions far from optimally due to a high internal resistance of the fuel cell, a mediator not functioning optimally, limited electrode surface area and oxygen diffusion of the air to the anolyte in the beaker. After being in operation for a week, the microbial fuel cell is still operating and producing roughly the same power. It will be apparent to the skilled person that this microbial fuel cell can be readily optimized.

The present invention is by no means limited to the above described preferred embodiments. The rights sought are defined by the following claims, within the scope of which many modifications can be envisaged. It is for instance possible to apply sensor principles 2, 28 to a known microbial electrolysis cell. Such a cell can hereby be applied as a sensor for the detection of inter alia the influence of vibrations on biological systems. The biological activity of a system can be determined from the current which begins to flow at a determined overproduction between the anode and cathode. It is noted that sensor principle 28 can also be applied advantageously in this application.

Claims

1. Sensor for measuring effects of vibrations and/or fields on a micro-organism, comprising:

- an anolyte space for containing a micro-organism and an anolyte;
- an anode placed in the anolyte space for receiving electrons originating from the micro-organism;
- a catholyte space; and
- a cathode placed in the catholyte space,

wherein the anode and the cathode are operatively connected such that a current and/or current difference is measurable as a result of an applied vibration or an electric and/or magnetic field.

2. Sensor as claimed in claim 1, wherein the anolyte space comprises a mediator for receiving the electrons from the micro-organism and relinquishing them to the anode.

3. Sensor as claimed in claim 1 or 2, wherein the sensor makes use of a redox couple.

4. Sensor as claimed in claim 3, wherein the redox couple comprises a ferricyanide/ferrocyanide couple.

5. Sensor as claimed in one or more of the claims 1-4, wherein the cathode comprises a biocathode.

6. Sensor as claimed in one or more of the claims 1-5, wherein circulation means are provided for circulating anolyte through a separate space.

7. Sensor as claimed in one or more of the claims 1-6, wherein the micro-organism comprises yeast, such as bakers' yeast.

8. Sensor as claimed in one or more of the claims 1-7, wherein the anolyte comprises diluted juice concentrate, such as apple juice.

9. Sensor as claimed in one or more of the claims 1-8, wherein a membrane is provided as separation between the anolyte space and the catholyte space.

10. Sensor as claimed in one or more of the claims 1-9, wherein an absorbing element is provided between the anolyte space and the cathode.

11. Sensor as claimed in claim 10, wherein the absorbing element comprises a cotton cloth.

12. Sensor as claimed in claim 10 or 11, wherein the absorbing element is provided continuously or periodically with anolyte.

13. Bioreactor for producing and/or selecting a micro-organism, comprising:

- a reactor vessel for containing a micro-organism;
- means for applying vibrations such as acoustic vibrations and/or an electric or magnetic field in order to influence the micro-organism.

14. Microbial fuel cell, comprising:

- an anolyte space for containing a micro-organism and an anolyte;
- an anode placed in the anolyte space for receiving electrons originating from the micro-organism;
- a cathode; and
- an absorbing element placed between the anolyte space and the cathode.

15. Method for influencing a micro-organism, comprising the steps of:

- providing the micro-organism in an anolyte space;

- placing an anode in the anolyte space;
- providing a cathode operatively connected to the anode such that a voltage occurs between the anode and the cathode; and
- exposing a micro-organism to vibrations, such as acoustic vibrations, an electric field and/or a magnetic field.

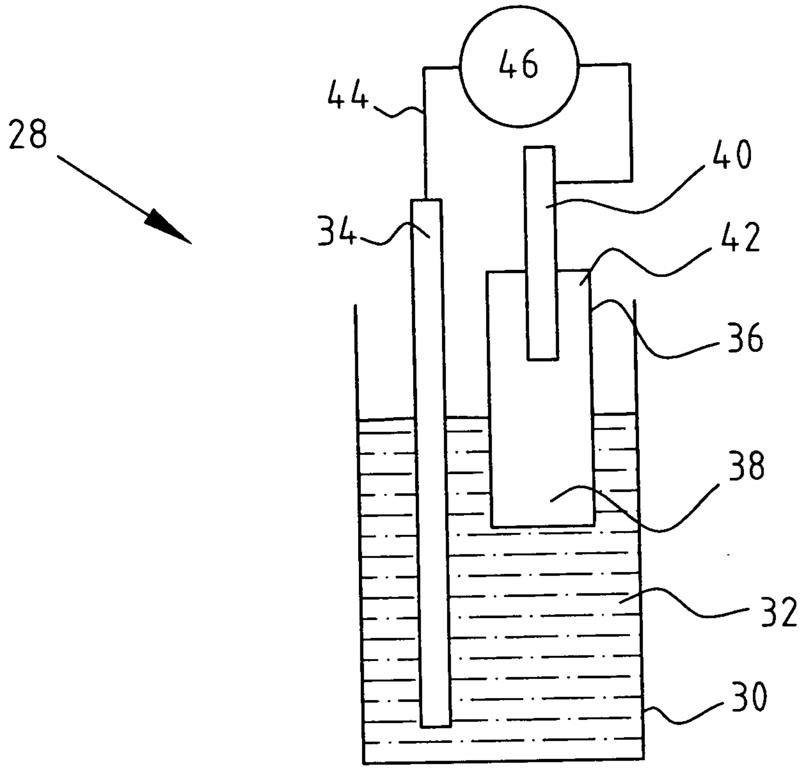

FIG. 2

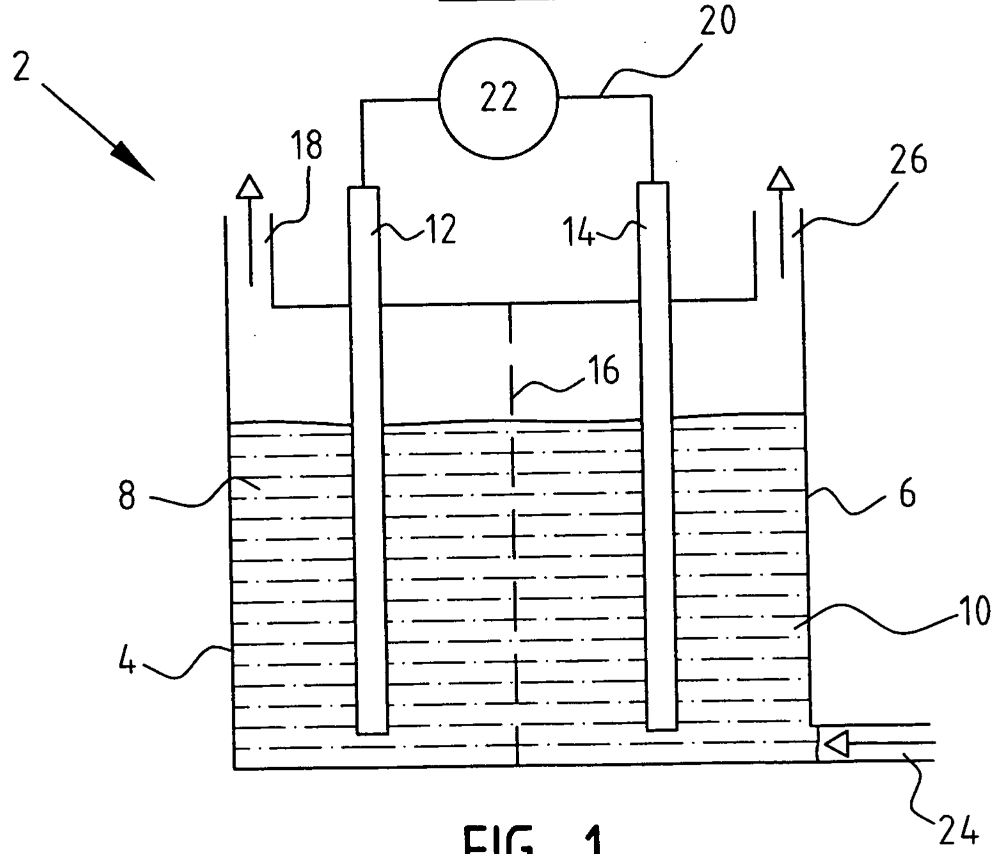

FIG. 1

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2009/000038

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01N27/416 C12M1/34

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G01N C12M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2006/044954 A (UNIV FLORIDA [US]; RINZLER ANDREW G [US]; INGRAM LONNIE O'NEAL [US]; S) 27 April 2006 (2006-04-27)	14
Y	paragraphs [0003] - [0008] paragraphs [0017] - [0021]; figures	1-13,15
Y	US 6 297 025 B1 (SUGIHARA HIROKAZU [JP] ET AL) 2 October 2001 (2001-10-02) column 1, line 58 - column 2, line 9 column 3, line 18 - line 21	1-13,15
A	WO 01/04626 A (KOREA INST SCIENCE TECHNOLOGY [KR]; KIM BYUNGHONG [KR]; CHANG INSEOP [) 18 January 2001 (2001-01-18) page 4, line 21 - line 30	1-15

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
2 June 2009	08/06/2009

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Savage, John

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2009/000038

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	YANG S ET AL: "The ultrasonic effect on biological characteristics of Monascus sp" ENZYME AND MICROBIAL TECHNOLOGY, STONEHAM, MA, US, vol. 37, no. 1, 1 June 2005 (2005-06-01), pages 139-144, XP025278630 ISSN: 0141-0229 [retrieved on 2005-06-01] page 142, right-hand column -----	1-15
A	ABDULLAH ET AL: "Feasibility study of a mini fuel cell to detect interference from a cellular phone" JOURNAL OF POWER SOURCES, ELSEVIER, AMSTERDAM, NL, vol. 155, no. 2, 21 April 2006 (2006-04-21), pages 311-318, XP005365142 ISSN: 0378-7753 paragraph [03.1] -----	1-15

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/NL2009/000038

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