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(54) **Bio-electrochemical device and method for upgrading a fluid.**

(57) The invention relates to a device for upgrading a fluid, and a system and method therefore. The device comprises:
- a housing for containing the fluid;
- an anode compartment provided with an anode, and a cathode compartment provided with a cathode; and
- an upgrading compartment separated from the anode compartment by a first membrane and separated from the cathode compartment by a second membrane.

NL C 2003812

BIO-ELECTROCHEMICAL DEVICE AND METHOD FOR UPGRADING A FLUID

The present invention relates to a bio-electrochemical device for upgrading a fluid. More specifically, the device can be used to upgrade a liquid flow, like a waste water flow, to enable the use of the liquid flow for energy generation or the production of hydrogen, for example.

Bio-electrochemical devices are known to be able to degrade organic matter using bacteria to produce a current and thereby energy. Such system is a microbial fuel cell, for example. In a similar configuration, such as a microbial electrolysis cell, hydrogen is produced. This energy generation or hydrogen production requires a fluid with sufficiently high alkalinity and salt concentrations. In practice alkalinity and concentrations limit scaling up the systems and/or the applicability thereof.

The object of the present invention is to improve the applicability of bio-electrochemical devices.

This object is achieved with the bio-electrochemical device according to the invention for upgrading a fluid, the device comprising:

- a housing for containing the fluid;
- an anode compartment provided with an anode, and a cathode compartment provided with a cathode; and
- an upgrading compartment separated from the anode compartment by a first membrane and separated from the cathode compartment by a second membrane.

A bio-electrochemical device comprises an anode compartment provided with an anode and a cathode compartment provided with a cathode. At the anode organic material is oxidized to electrons, protons and CO_2. At the cathode oxygen in case of a microbial fuel cell (MFC), or protons in case of a microbial electrolysis cell (MEC), are reduced to water

and hydrogen, respectively. Electrons move from anode to cathode. To compensate this movement of negative force, cations move from anode to cathode and/or anions move from cathode to anode. The system according to the invention further comprises an upgrading compartment that is separated from the anode compartment by a first membrane and is separated from the cathode compartment by a second membrane. Because of the flow of electrons cations and anions will be transported towards this upgrading compartment. This increases the pH and the conductivity of the fluid in the upgrading compartment. This upgrades the fluid in this compartment and enables the use thereof in a MFC for energy generation and/or a MEC for hydrogen production, for example.

The conductivity of waste water is often in the order of 2 ms/cm. Such level of conductivity limits the applicable distance between the anode and cathode. In experiments a limit of about 1 mm was determined. This relatively small distance prevents practical application of bio-electrochemical devices using these waste water flows. Providing these flows with additional salts is rather expensive and does not contribute to the sustainability of the system. In addition, such added salts should be removed before disposing the fluid that is used. This is especially relevant in case the fluid comprises waste water, for example.

By upgrading a fluid, such as the waste water flow mentioned above, the efficiency of operations involving a MFC and/or MEC can be improved by using the upgraded fluid.

In addition, at present flows are often not usable for use in bio-electrochemical systems. Such flows can be upgraded by incorporating the device according to the invention in the bio-electrochemical system. This

incorporation in a bio-electrochemical system according to the invention increases the amount of flows that can be used. Furthermore, by improving the properties of the flows also the possibilities of scaling up the systems are improved. This contributes to large scale energy generation or hydrogen production, for example.

By upgrading the fluid in the upgrading compartment, the pH is increased. For example, this enables treatment of waste streams with solid particles. In fact, such solid particles are made available for oxidation. Another application is degrading the organic matter in volatile fatty acids. At present the degrading of organic matter is limited by the decreasing pH as function of the acids that are produced. The upgrading the fluid in the bio-electrochemical system according to the invention enables further acidification. This improves the efficiency of this process.

Preferably, the first membrane comprises a cation exchanging membrane, while the second membrane comprises an anion exchange membrane. The anode is separated from the cathode by a cation selective membrane on the anode side and an anion selective membrane on the cathode side of the upgrading compartment. Cations are transported from the anode compartment to the upgrading compartment and anions are transported form the cathode compartment to the upgrading compartment. This upgrades the fluid in the upgrading compartment. Preferably, the anode and/or cathode comprise biochemical active micro-organisms. Also preferably, the fluid in the upgrading compartment comprises waste water. This enables the use and/or re-use of a waste water flow.

The bio-electrochemical system according to the invention can be operated as a batch process by maintaining

an amount of liquid in the upgrading compartment for a period of time, or as a continuous process by maintaining a continuous flow through this upgrading compartment.

Energy can be generated or hydrogen produced by providing the upgraded flow with the system according to the invention to a MFC and/or a MEC. Other processes in the production of energy and hydrogen are also possible using the upgrading system according to the invention. For example, the upgraded flow can be used to produce volatile fatty acids.

The invention also relates to a bio-electrochemical system for generating energy or providing hydrogen, comprising:

- a microbial fuel cell for energy generation or a microbial electrolysis cell;
- supply means for supplying a fluid to the cell; and
- an upgrading system including a bio-electrochemical device as described above.

Such system provides the same effects and advantages as those related to the device.

In a preferred embodiment according to the present invention the upgrading device acts as a pre-treatment system for pre-treating a fluid.

Providing the device with coupling means for coupling the device to a process device, like a MFC or a MEC, results in the bio-electrochemical device being used as a pre-treatment system in the system according to the invention. The device upgrades the fluids before processing this fluid in the system. An advantage thereof is that the processing device can be operated efficiently for upgrading the flow. Also, this configuration has the additional advantage that the pre-treatment can be performed without requiring significant changes to the existing processing system. This

improves the applicability of different types of flows, like waste water flows, for processing devices including MFC's and MEC's. Depending on the specific conditions, the entire flow, or part thereof, can be pre-treated in the device according to the invention.

In a preferred embodiment according to the present invention the bio-electrochemical device acts as regenerating system for regenerating the fluids, the device comprising coupling means for coupling the device to a processing device.

By providing coupling means the bio-electrochemical device according to the invention can be coupled to a processing device, like a MFC and MEC. This enables a post-treatment operation in the device according to the invention. By regenerating the fluid the (partly) regenerated fluid can be recycled to the processing device, thereby improving the overall efficiency of the processing operation. A further advantage of regenerating the fluid in the device according to the invention is the applicability of the device in combination with existing processing equipment. Depending on the specific conditions of the processing operation the flow can be recycled in its entirety or in part.

In addition, the device according to the invention can be used as pre-treatment and/or as post-treatment operation. This can be achieved by alternately operating the bio-electrochemical device according to the invention as pre-treatment and post-treatment device, or by providing different devices for the different operations.

The present invention also relates to a method for upgrading a fluid comprising the steps of:

- providing a fluid to a bio-electrochemical device as described above; and

- providing a potential difference and/or a resistance between electrodes in the device.

Such method provides the same effects and advantages as those related to the device. The method according to the invention can be applied to a batch operation or a continuous operation like described above.

The upgrading of the fluids can be performed as a pre-treatment operation. The upgraded flow is provided to a MFC for generating energy or MEC for providing hydrogen or performing another bio-electrochemical operation. The upgraded fluid can also be provided to other alternative process operations. Furthermore, the method for upgrading a fluid can also be performed for recycling an entire fluid or a part thereof after energy is generated or hydrogen is produced, for example. Also the method can be performed as a pre-treatment and post-treatment operation.

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

- figure 1 illustrates a bio-electrochemical device according to the invention;
- figure 2 shows results with the device of figure 1; and
- figure 3 also shows results of the device of figure 1.

A bio-electrochemical device (figure 1) comprises a housing or container 4. Container 4 comprises an anode compartment 6 with an anode 8 whereon micro-organisms 10 are provided. Container 4 further comprises a cathode compartment 12 that is provided with a cathode 14. Between anode compartment 6 and cathode compartment 12 there is provided an upgrading compartment 16. Upgrading compartment 16 is separated from anode compartment 6 by a cation

exchanging membrane 16. Upgrading compartment 16 is separated from cathode compartment 12 by anion exchanging membrane 20. Inlet 22 provides upgrading compartment 16 with a flow with a relatively low pH and a low conductivity. The upgraded fluid leaves upgrading compartment 16 through outlet 25. The influent is provided to the anode compartment 6 through inlet 26 and the effluent leaves compartment 6 through outlet 28, while hydrogen produced in the cathode compartment 12 leaves through outlet 30. A current or power source 32 is connected by circuit 34 to the electrodes 8, 14.

At anode 8 micro-organisms 10 oxidize organic material to electrons, protons and CO_2. At the cathode oxygen or protons are reduced to water and hydrogen. Electrons move from anode 8 to cathode 14 through circuit 34. This provides a driving force causing cations to move from anode compartments 6 towards cathode compartment 12 and anions to move from cathode compartment 12 towards anode compartment 6. By separating compartments 6, 12 with membranes 18, 20 cations from the anode compartment and anions from the cathode compartment 12 are transported to the upgrading compartment 16, thereby improving the pH and conductivity of the fluids in compartment 16.

In an experiment device 2 is used to upgrade a fluid. The pH (figure 2) and the conductivity (mS/cm) (figure 3) are measured of both the incoming influents (indicated with I and filled circles) and the fluid in the upgrading compartment 16 (indicated with B and open circles). Measurements are performed during a time period of seven days. The results indicate a strong increase in pH and conductivity C of the fluid in the upgrading compartment 16. This illustrates the applicability of upgrading a fluid like

waste water, for example. This upgraded flow can be used for energy generation or hydrogen production.

The present invention is by no means limited to the above described preferred embodiments thereof. The rights sought are defined by the following claims within the scope of which many modifications can be envisaged.

Clauses

1. Bio-electrochemical device for upgrading a fluid, the device comprising:
   - a housing for containing the fluid;
   - an anode compartment provided with an anode, and a cathode compartment provided with a cathode; and
   - an upgrading compartment separated from the anode compartment by a first membrane and separated from the cathode compartment by a second membrane.

2. Bio-electrochemical device according to clause 1, wherein the first membrane is a cation exchanging membrane and the second membrane is an anion exchanging membrane.

3. Bio-electrochemical device according to clause 1 or 2, the anode and/or cathode comprising bio-chemical active micro-organisms.

4. Bio-electrochemical device according to clause 1, 2 or 3, wherein the fluid comprises waste water.

5. Bio-electrochemical system for generating energy or providing hydrogen, comprising:
   - a microbial fuel cell for energy generation or a microbial electrolysis cell;
   - supply means for supplying a fluid to the cell; and
   - an upgrading system including a bio-electrochemical device according to any of the clauses 1-4.

6. Bio-electrochemical system according to clause 5, wherein the bio-electrochemical device acting as a pre-treatment system for pre-treating the fluid, the device comprising coupling means for coupling the device to the cell.

7. Bio-electrochemical system according to clause 5 or 6, wherein the bio-electrochemical device acting as a regenerating system for regenerating the fluid, the device comprising coupling means for coupling the device to the cell.

8. Method for upgrading a fluid, comprising the steps of:
- providing a fluid to a bio-electrochemical device according to any of the clauses 1-4; and
- providing a potential difference and/or a resistance between electrodes in the device.

9. Method according to clause 8, wherein after upgrading the fluid is provided to a microbial fuel cell for generating energy or a microbial electrolysis cell for providing hydrogen or performing another bio-electrochemical operation.

10. Method according to clause 8 or 9, wherein upgrading the fluid is performed after energy is generated or hydrogen is provided using the fluid for enabling re-use of the fluid.

Conclusies

1. Bio-electrochemische inrichting voor het opwaarderen van een fluïdum, waarbij de inrichting omvattende:
   - een behuizing voor het bevatten van het fluidum;
   - een anode compartiment voorzien van een anode en een kathode compartiment voorzien van een kathode; en
   - een opwaarderings-compartiment gescheiden door een eerste membraan van het anode compartiment en door een tweede membraan gescheiden van het kathode compartiment.

2. Bio-electrochemische inrichting, volgens conclusie 1, waarin het eerste membraan een cation uitwisselend membraan omvat en een tweede membraan een anion uitwisselend membraan omvat.

3. Bio-electrochemische inrichting volgens conclusie 1 of 2, de anode en/of kathode omvattende biochemisch actieve micro-organismen.

4. Bio-electrochemische inrichting volgens conclusie 1, 2 of 3, waarin het fluïdum omvattende afvalwater.

5. Bio-electrochemisch systeem voor het genereren van energie of het voorzien van waterstof, omvattende:
   - een microbiële brandstofcel voor het genereren van energie of een microbiële elektrolyse cel;
   - toevoermiddelen voor het toevoeren van een fluïdum naar de cel;
   - een opwaarderingssysteem omvattende een bio-electrochemische inrichting volgens één of meer van de conclusies 1-4.

6. Bio-electrochemisch systeem volgens conclusie 5, waarin de bio-electrochemische inrichting opererend als een voorbehandelingsysteem voor het voorbehandelen van een fluïdum en het systeem omvattende koppelingsmiddelen voor het koppelen van de inrichting aan de cel.

7. Bio-electrochemisch systeem volgens conclusie 5 of 6, waarin de bio-electrochemische inrichting opererend als een regenererend systeem voor het regenereren van het fluïdum, het systeem omvattende koppelingsmiddelen voor het koppelen van de inrichting aan de cel.

8. Werkwijze voor het opwaarderen van een fluïdum, omvattende de stappen:
   - het voorzien van een fluïdum aan een bio-electrochemische inrichting volgens één of meer van de conclusies 1-4; en
   - het voorzien van een potentiaalverschil en/of een weerstand tussen de elektroden in de inrichting.

9. Werkwijze volgens conclusie 8, waarin na het opwaarderen het fluïdum wordt voorzien aan een microbiële brandstofcel voor het genereren van energie of aan een microbiële elektrolysecel voor het voorzien van waterstof of het uitvoeren van een ander bio-elektrochemische operatie.

10. Werkwijze volgens conclusie 8 of 9, waarin het opwaarderen van het fluïdum wordt uitgevoerd na het genereren van energie of produceren van waterstof, gebruikmakend van het fluïdum voor het mogelijk maken van hergebruik van het fluïdum.

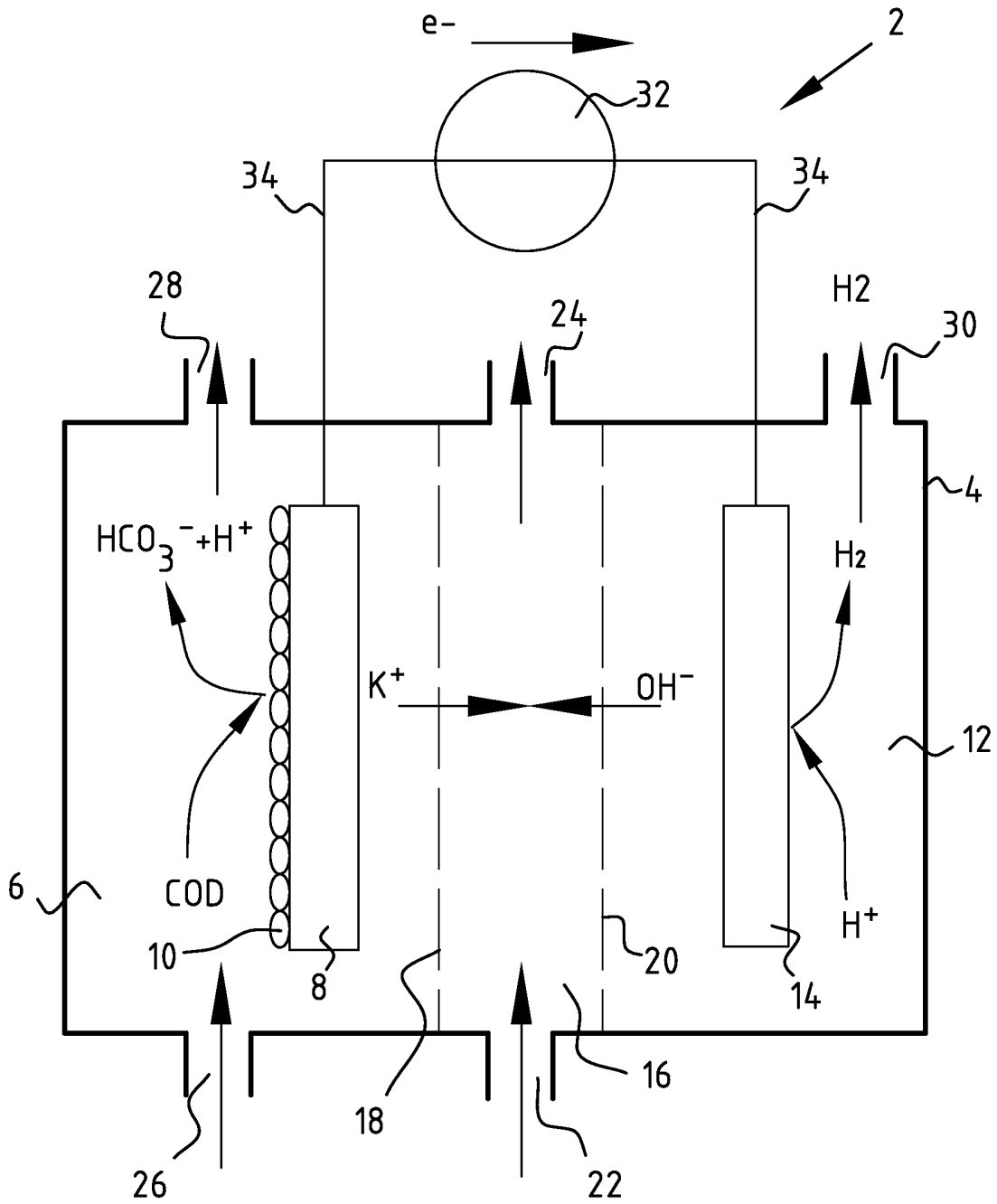

FIG. 1

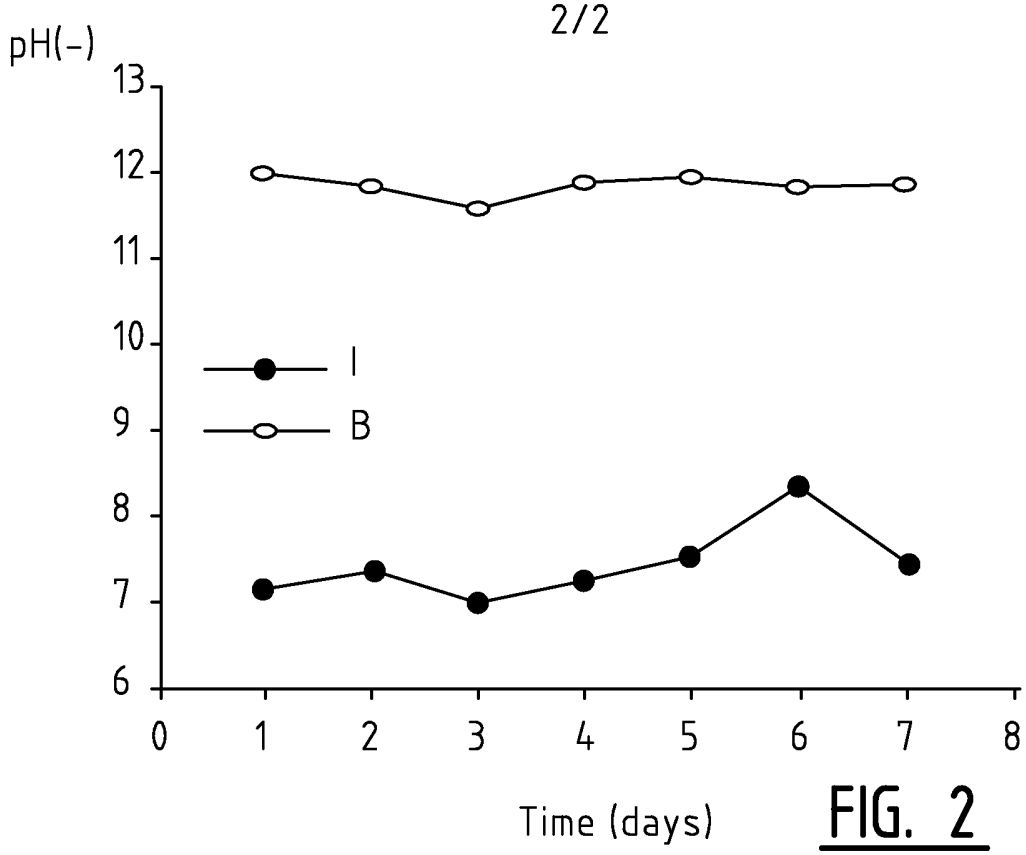
pH(-)
13
12
11
10
9
8
7
6
I
B
0
1
2
3
4
5
6
7
8
Time (days)

FIG. 2

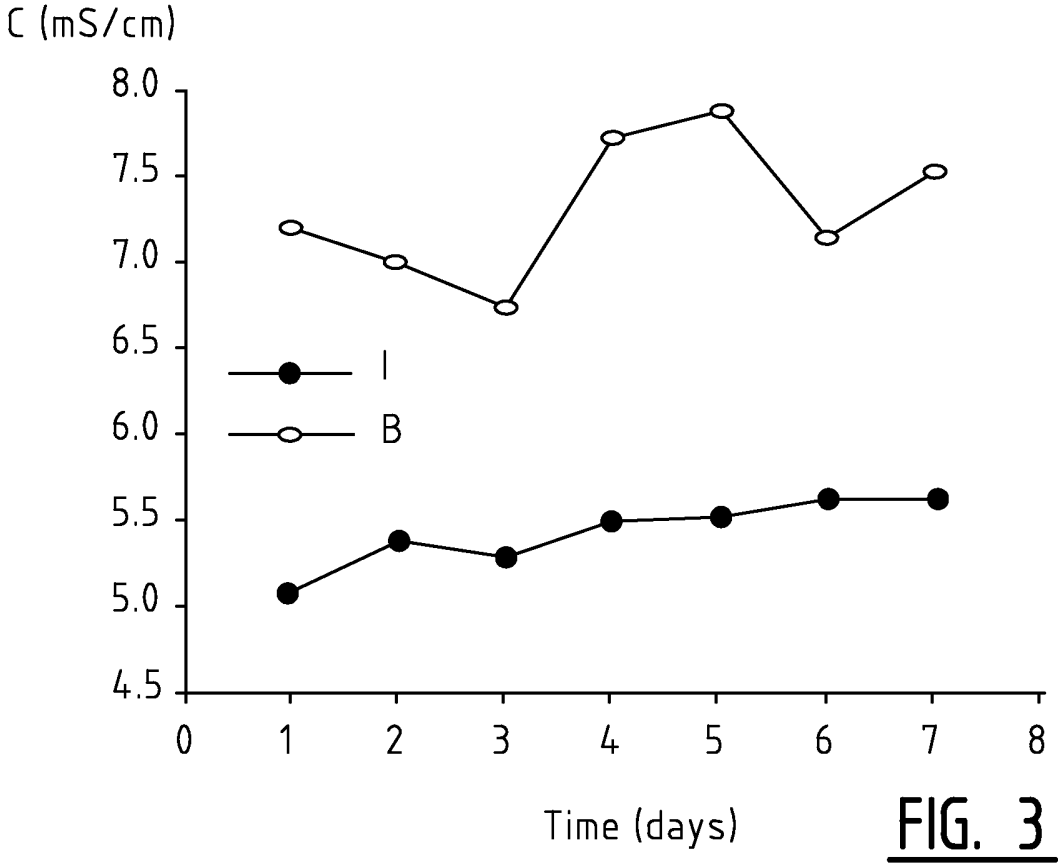
C (mS/cm)
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
I
B
0
1
2
3
4
5
6
7
8
Time (days)

FIG. 3

SAMENWERKINGSVERDRAG (PCT)

RAPPORT BETREFFENDE NIEUWHEIDSONDERZOEK VAN INTERNATIONAAL TYPE

IDENTIFICATIE VAN DE NATIONALE AANVRAGE	KENMERK VAN DE AANVRAGER OF VAN DE GEMACHTIGDE
	2L/2HQ67/ED-36
Nederlands aanvraag nr. **2003812**	Indieningsdatum **17-11-2009**
	Ingeroepen voorrangsdatum

Aanvrager (Naam)

Stichting Wetsus Centre of Excellence for Sustainable Water Technology

Datum van het verzoek voor een onderzoek van internationaal type	Door de Instantie voor Internationaal Onderzoek aan het verzoek voor een onderzoek van internationaal type toegekend nr.
26-11-2009	**SN 53455**

I. CLASSIFICATIE VAN HET ONDERWERP (bij toepassing van verschillende classificaties, alle classificatiesymbolen opgeven)

Volgens de internationale classificatie (IPC)

H01M8/16 **H01M8/22**

II. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK

Onderzochte minimumdocumentatie

Classificatiesysteem	Classificatiesymbolen
IPC8	**H01M**

Onderzochte andere documentatie dan de minimum documentatie, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

III.	☐	**GEEN ONDERZOEK MOGELIJK VOOR BEPAALDE CONCLUSIES**	(opmerkingen op aanvullingsblad)
IV.	☐	**GEBREK AAN EENHEID VAN UITVINDING**	(opmerkingen op aanvullingsblad)

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Nummer van het verzoek om een onderzoek naar de stand van de techniek
NL 2003812

A. CLASSIFICATIE VAN HET ONDERWERP
INV. H01M8/16 H01M8/22
ADD. H01M16/00

Volgens de Internationale Classificatie van octrooien (IPC) of zowel volgens de nationale classificatie als volgens de IPC.

B. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK

Onderzochte miminum documentatie (classificatie gevolgd door classificatiesymbolen)
H01M

Onderzochte andere documentatie dan de mimimum documentatie, voor dergelijke documenten, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

Tijdens het onderzoek geraadpleegde elektronische gegevensbestanden (naam van de gegevensbestanden en, waar uitvoerbaar, gebruikte trefwoorden)
EPO-Internal, WPI Data

C. VAN BELANG GEACHTE DOCUMENTEN

Categorie °	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
X	GB 2 249 785 A (IONICS ITALBA SPA [IT]) 20 mei 1992 (1992-05-20)	1-4,8
Y	* bladzijde 1, regel 1 - regel 10 * * bladzijde 6, regel 9 - bladzijde 8, regel 30 * * conclusie 1 * * figuur 2 * --- -/--	5-7,9,10

[X] Verdere documenten worden vermeld in het vervolg van vak C.

[X] Leden van dezelfde octrooifamilie zijn vermeld in een bijlage

° Speciale categorieën van aangehaalde documenten

"A" niet tot de categorie X of Y behorende literatuur die de stand van de techniek beschrijft

"D" in de octrooiaanvrage vermeld

"E" eerdere octrooi(aanvrage), gepubliceerd op of na de indieningsdatum, waarin dezelfde uitvinding wordt beschreven

"L" om andere redenen vermelde literatuur

"O" niet-schriftelijke stand van de techniek

"P" tussen de voorrangsdatum en de indieningsdatum gepubliceerde literatuur

"T" na de indieningsdatum of de voorrangsdatum gepubliceerde literatuur die niet bezwarend is voor de octrooiaanvrage, maar wordt vermeld ter verheldering van de theorie of het principe dat ten grondslag ligt aan de uitvinding

"X" de conclusie wordt als niet nieuw of niet inventief beschouwd ten opzichte van deze literatuur

"Y" de conclusie wordt als niet inventief beschouwd ten opzichte van de combinatie van deze literatuur met andere geciteerde literatuur van dezelfde categorie, waarbij de combinatie voor de vakman voor de hand liggend wordt geacht

"&" lid van dezelfde octrooifamilie of overeenkomstige octrooipublicatie

Datum waarop het onderzoek naar de stand van de techniek van internationaal type werd voltooid	Verzenddatum van het rapport van het onderzoek naar de stand van de techniek van internationaal type
12 april 2010	
Naam en adres van de instantie European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	De bevoegde ambtenaar Standaert, Frans

2

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Nummer van het verzoek om een onderzoek naar de stand van de techniek
NL 2003812

C.(Vervolg). VAN BELANG GEACHTE DOCUMENTEN

Categorie °	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
X	VIRDIS B ET AL: "Microbial fuel cells for simultaneous carbon and nitrogen removal" WATER RESEARCH, ELSEVIER, AMSTERDAM, NL LNKD- DOI:10.1016/J.WATRES.2008.03.017, deel 42, nr. 12, 1 juni 2008 (2008-06-01), bladzijden 3013-3024, XP022709897 ISSN: 0043-1354 [gevonden op 2008-04-08]	1-4,8
Y	* bladzijde 3013, linker kolom, regel 1 - bladzijde 3014, rechter kolom, laatste regel *	5-7,9,10
A	KR 2008 0020012 A (SEOUL NAT UNIVERSITY OF TECHNO [KR]) 5 maart 2008 (2008-03-05) * samenvatting *	1-10

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Informatie over leden van dezelfde octrooifamilie

Nummer van het verzoek om een onderzoek naar de stand van de techniek
NL 2003812

In het rapport genoemd octrooigeschrift	Datum van publicatie	Overeenkomend(e) geschrift(en)	Datum van publicatie
GB 2249785 A	20-05-1992	DE 4137725 A1	21-05-1992
		FR 2669324 A1	22-05-1992
		IL 99932 A	30-03-1995
		IT 1245742 B	14-10-1994
KR 20080020012 A	05-03-2008	GEEN	

OCTROOICENTRUM NEDERLAND

WRITTEN OPINION

File No.	Filing date *(day/month/year)*	Priority date *(day/month/year)*	Application No.
SN53455	17.11.2009		NL2003812

International Patent Classification (IPC)
INV. H01M8/16 H01M8/22
ADD. H01M16/00

Applicant
Stichting Wetsus Centre of Excellence for Sustaina

This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the application
- ☒ Box No. VIII Certain observations on the application

	Examiner
	Standaert, Frans

Application number

WRITTEN OPINION

NL2003812

Box No. I Basis of this opinion

1. This opinion has been established on the basis of the latest set of claims filed before the start of the search.

2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the application and necessary to the claimed invention, this opinion has been established on the basis of:

   a. type of material:

   ☐ a sequence listing

   ☐ table(s) related to the sequence listing

   b. format of material:

   ☐ on paper

   ☐ in electronic form

   c. time of filing/furnishing:

   ☐ contained in the application as filed.

   ☐ filed together with the application in electronic form.

   ☐ furnished subsequently for the purposes of search.

3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

4. Additional comments:

Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty	Yes:	Claims	5-7, 9, 10
	No:	Claims	1-4, 8
Inventive step	Yes:	Claims	
	No:	Claims	1-10
Industrial applicability	Yes:	Claims	1-10
	No:	Claims	

2. Citations and explanations

see separate sheet

Application number

WRITTEN OPINION

NL2003812

Box No. VIII Certain observations on the application

see separate sheet

Re Item V

Reference is made to the following documents:

D1 GB 2 249 785 A (IONICS ITALBA SPA [IT]) 20 mei 1992 (1992-05-20)

D2 VIRDIS B ET AL: "Microbial fuel cells for simultaneous carbon and nitrogen removal"WATER RESEARCH, ELSEVIER, AMSTERDAM, NL LNKD- DOI:10.1016/J.WATRES.2008.03.017, deel 42, nr. 12, 1 juni 2008 (2008-06-01) , bladzijden 3013-3024, XP022709897ISSN: 0043-1354 [gevonden op 2008-04-08]

The present application does not meet the criteria of patentability, because the subject-matter of claims 1-10 does not involve an inventive step, for the following reasons.

Both documents D1 and D2 relate to the removing of nitrogen based compounds from waste-water (see the passages provided by the search report). Document D1 also states that the described electrodialysis should be combined with a biological denirtrification reactor, see page 8, lines 15-16. Examples of biological denirtrification reactors are provided by D2.

Document D1 does not relate to a bio-electrochemical device, but discloses all other features of claims 1-4 and 8. The use of a bio-anode or bio-cathode within the electrodialysis device disclosed by document D1 is merely one of several straight-forward possibilities from which the skilled person would select, in accordance with circumstances (i.e. type of material that has to be removed together with the nitrates from the water), without the exercise of inventive skill, thereby arriving at the subject-matter of claims 1-4 and 8.

With regard to claims 5-7, 9 and 10 it should be noted that the general teaching of document D1 can be applied to the recirculation loop of the bio-electrochemical system depicted in Figure 1 of document D1. That is, for the skilled person it is clear that an electrodialysis device, of which the principles are explained by D1, can be inserted downstream of the nitrification reactor (4) in Figure 1 of D2. Furthermore document D2 (page 314, left-hand column, last paragraph) also discloses that denitrification is possible by electrolyse using a biocathode. Therefore the subject-matter of claims 1-10 seems to represent a mere juxtaposition of known features, without any unexpected effect in support of an inventive step.

Re Item VIII

The term "upgrading a fluid" used in the independent claims 1 and 8 is vague and unclear and leaves the reader in doubt as to the meaning of the technical feature to which it refers, thereby rendering the definition of the subject-matter of said claims unclear.