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(54) **BIPOLAR PLATE FOR USE IN PEM ELECTROLYSIS DEVICE, AND PEM ELECTROLYSIS DEVICE**

(57) The present disclosure relates to a bipolar plate (1) for use in a PEM electrolysis device (3). The bipolar plate (1) is composed of a composite material with at least one polymer material as a base material; and comprises a cathode side (3) made of a composite material containing carbon filling particles, and an anode side (4) made of a composite material containing metal particles, metal carbide particles, metal nitride particles and tin oxide particles. The present invention further relates to a PEM electrolysis device (2) having at least one such bipolar plate (1).

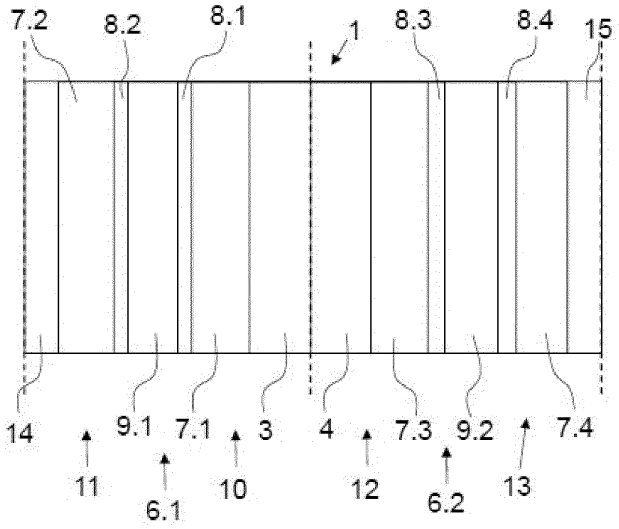

FIG. 1

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Description

Technical Field

[0001] The present invention relates to a bipolar plate for use in a PEM electrolysis device. The present invention further relates to a PEM electrolysis device having at least one such bipolar plate.

Background

[0002] A PEM electrolysis device (PEM = proton exchange membrane) is used for the acidic electrolysis of water into oxygen and hydrogen. The anode and cathode are separated from each other by a proton conducting membrane. A bipolar plate provided as a battery separator in the PEM electrolysis device separates the anode space and the cathode space of the PEM electrolysis device from each other. The bipolar plate on the cathode side is usually composed of titanium plates. Titanium in the PEM electrolysis device can add hydrogen and thus cause hydrogen embrittlement, which reduces the operating time of the bipolar plate and thereby the operating time of the electrolysis device. Hydrogen embrittlement can be reduced by coating at least the hydrogen-exposed cathode side of the bipolar plate with carbon.

[0003] A bipolar plate for an electrochemical battery is known, for example, from DE 10 2014 109 321 A1. The bipolar plate comprises a substrate having a substrate surface and a coating applied to at least a portion of the substrate surface. The coating comprises a rough and/or porous covering layer which is applied to the substrate surface in a plasma metal spraying process and has a rough and/or porous covering layer surface pointing away from the substrate. The coating also comprises a protective layer, wherein the covering layer surface is provided or covered with the protective layer. The substrate is configured with a flat plate shape and is made of steel, in particular stainless steel, copper and/or aluminum.

[0004] Furthermore, DE 10 2013 207 082 A1 discloses a PEM electrolysis device comprising a battery separator with a steel/titanium bimetallic plate.

Summary

[0005] The objective of the present invention is to provide an alternative bipolar plate for use in a PEM electrolysis device and an alternative PEM electrolysis device. In particular, the bipolar plate can be produced cost-effectively and has high corrosion resistance as well as high oxidation resistance. In addition, the PEM electrolysis device can also have higher efficiency and longer service life.

[0006] The objective is achieved by the bipolar plate having the feature of Claim 1 and by the PEM electrolysis device having the feature of Claim 10. Preferred or advantageous embodiments of the present invention are derived from the dependent claims and the following description and drawings.

[0007] A bipolar plate for use in a PEM electrolysis device according to the present invention is composed of at least one polymer material, and has a cathode side comprising carbon filling particles and an anode side comprising metal particles, metal carbide particles and/or metal nitride particles. In other words, the bipolar plate is configured in a multiple-layer manner, wherein at least two layers are provided with different functions and/or properties. In particular, the bipolar plate is composed of at least one composite material. The layer forming the cathode side and the layer forming the anode side are inseparably connected to one another, in particular via positive locking and/or material connection. For example, the cathode side and the anode side of the bipolar plate are connected to each other indirectly via another layer or another element, or immediately adjacent, i.e., directly inseparably connected to one another.

[0008] For example, polymer mixtures composed of at least one polymer and carbon filling particles and of at least one polymer material and metal particles, metal carbide particles and/or metal nitride particles can be injection molded, in particularly by injection molding or pressure casting, into the bipolar plate. Alternatively, polymer mixtures composed of at least one polymer and carbon filling particles and of at least one polymer material and metal particles, metal carbide particles and/or metal nitride particles can be pressed, in particular by rolling, deformation, molding, into the bipolar plate. In particular, it is also possible to combine these methods with one another, so that the bipolar plate is first injection molded and then pressed.

[0009] According to a preferred embodiment of the present invention, the metal particles, metal carbide particles and metal nitride particles are selected from titanium, niobium, silver, gold, platinum, iridium, titanium carbide, niobium carbide, titanium nitride and niobium nitride. As an alternative or supplement to this, using metered or unmetered tin oxide on the anode side can also be envisaged. In particular, metal particles, metal carbide particles and metal nitride particles are oxidation-resistant and have higher oxidation resistance than carbon filling particles.

[0010] According to a preferred embodiment of the present invention, the carbon filling particles are selected from carbon black, graphite, graphene, carbon fibers and carbon nanotubes. In particular, the carbon filling particles are electrically conductive. Preferably, the content of carbon filling particles in at least one polymer material on the cathode side is at least 70 vol.%. For example, the content of carbon filling particles in polymer materials can be determined by X-ray structural analysis (XRD). vol.% is an abbreviation for volume percent.

[0011] According to a preferred embodiment of the present invention, the bipolar plate is composed at least partly or completely of at least one thermoplastic selected from PP (polypropylene), PVF (polyvinyl fluoride), PVDF

(polyvinylidene fluoride), PTFE (polytetrafluoroethylene), PCTFE (polychlorotrifluoroethylene), ETFE (ethylene-tetrafluoroethylene fluorine copolymer), PA (polyamide), PPA (polyphthalamide), PPS (polyphenylene sulfide), LCP (liquid crystal polymer), PEEK (polyetheretherketone), PC (polycarbonate), PSU (polysulfone), PESU (polyethersulfone), and PEI (polyetherimide). In other words, the bipolar plate may be composed of at least one of the aforementioned thermoplastics or of a combination of at least two or more thermoplastics.

[0012] According to a preferred embodiment of the present invention, the bipolar plate is composed at least partly or completely of at least one thermosetting plastic selected from phenolic resins, epoxy resins, melamine resins, unsaturated polyester resins, polyimides and polyamide-imides. In other words, the bipolar plate may be composed of at least one of the aforementioned thermosetting plastics or of a combination of at least two or more thermosetting plastics.

[0013] According to a preferred embodiment of the present invention, the bipolar plate is composed at least partly or completely of at least one elastomer selected from FKM (fluororubber), FFKM (perfluororubber), EPDM (ethylene-propylene-diene rubber), CR (neoprene rubber), IIR (isobutylene-isoprene rubber), CSM (chlorosulfonyl-polyethylene rubber), FVMQ (fluorosilicone rubber). In other words, the bipolar plate may be composed of at least one of the aforementioned elastomers or of a combination of at least two or more elastomers. For example, the bipolar plate may be composed of a combination of two or more of the thermoplastics, thermosetting plastics, and elastomers described above.

[0014] According to a preferred embodiment of the present invention, a reinforcer is arranged at least partially or completely between the cathode side and the anode side. The reinforcer is used in particular to increase the rigidity of the bipolar plate. In other words, the bipolar plate has at least three layers, namely a layer forming the cathode side, a layer forming the anode side and a layer forming the reinforcer. All three layers are inseparably connected to one another, in particular via positive locking and/or material connection. Preferably, the reinforcer is configured as a metal mesh or a metal strip. For example, the metal mesh or metal strip is composed at least partially or completely of steel including a corrosion-resistant coating, stainless steel, especially a high-grade steel, copper, especially a copper alloy, and/or aluminum, especially an aluminum alloy. The surface of the metal mesh or metal strip is preferably rough and/or structured in order to be better attached to the at least one polymer material of the anode side and/or cathode side. Roughness or structures are produced on the surface of the metal mesh or metal strip, in particular by rolling, deformation, sandblasting and/or by means of laser processing.

[0015] If no reinforcer is used between the cathode side and the anode side, a resin packaging portion for reducing the gas diffusivity of the bipolar plate may be used between the cathode side and the anode side.

[0016] During the production of the bipolar plate by rolling, in particular during the production of composite materials or during the production of reinforcers, at least one roller can be heated and at least one roller can be cooled. The temperature influence during rolling can have a favorable effect on the properties of the bipolar plate, in particular on the structure and distribution of filling particles and metal elements in the polymer material.

[0017] A PEM electrolysis device according to the present invention comprises at least one bipolar plate according to the present invention. For example, the bipolar plate is provided as a battery separator in the PEM electrolysis device.

Brief Description of the Drawings

[0018] The improvement measures of the present invention will be described in detail below in combination with the accompanying drawings and the description of the preferred embodiments of the present invention. Shown here:

FIG. 1 shows a schematic view of a PEM electrolysis device having a bipolar plate configured as a battery separator according to a first embodiment, according to embodiments of the present invention,

FIG. 2 shows a schematic view of the bipolar plate in FIG. 1, and

FIG. 3 shows a schematic view of the bipolar plate according to a second embodiment.

Detailed Description

[0019] FIG. 1 shows a PEM electrolysis device 2 having two batteries 6.1 and 6.2 and a bipolar plate 1 arranged as a battery separator between the two batteries 6.1 and 6.2. In particular, the PEM electrolysis device 2 can comprise additional batteries, which are connected, for example, on both sides, wherein the batteries are separated from one another by the respective bipolar plate. The bipolar plate 1 is here configured in a two-layer manner and comprises a cathode side 3 and an anode side 4, wherein the cathode side 3 is composed of a first composite material and the anode side 4 is composed of a second composite material.

[0020] The first composite material is composed of a polymer having carbon filling particles. The second composite material is composed of a polymer having metal particles. Furthermore, as an alternative or supplement to metal particles, metal carbide particles and/or metal nitride particles may in particular be provided in the second polymer. In particular, the carbon filling particles are electrically conductive, and the metal particles are oxidation-resistant.

[0021] A porous transport layer 7.1 first adjoins on the

cathode side 3 of the bipolar plate 1, while a catalytic layer 8.1 is arranged on the transport side and a membrane 9.1 is arranged on the catalytic layer. The cathode side 3 of the bipolar plate 1 forms a cathode 10 together with the adjacent porous transport layer 7.1 and the catalytic layer 8.1. Arranged adjacent to the other side of the membrane 9.1 is a catalytic layer 8.2, on which is arranged a porous transport layer 7.2 and an anode side 14 of a further bipolar plate, not shown in detail, on the transport layer. The anode side 14 of the bipolar plate, not shown in detail, forms an anode 11 together with the adjacent porous transport layer 7.2 and the catalytic layer 8.2. The battery 6.1 extends from the anode side 14 of the bipolar plate, not shown in detail, to the cathode side 3 of the bipolar plate 1.

[0022] A porous transport layer 7.3 first adjoins on the anode side 4 of the bipolar plate 1, while a catalytic layer 8.3 is arranged on the transport side and a membrane 9.2 is arranged on the catalytic layer. The anode side 4 of the bipolar plate 1 forms an anode 12 together with the adjacent porous transport layer 7.3 and the catalytic layer 8.3. Arranged adjacent to the other side of the membrane 9.2 is a catalytic layer 8.4, on which is arranged a porous transport layer 7.4 and a cathode side 15 of a further bipolar plate, not shown in detail, on the transport layer. The cathode side 15 of the bipolar plate, not shown in detail, forms a cathode 13 together with the adjacent porous transport layer 7.4 and the catalytic layer 8.4. The battery 6.2 extends from the cathode side 15 of the bipolar plate, not shown in detail, to the anode side 4 of the bipolar plate 1.

[0023] The function of the PEM electrolysis device 1 and its individual components for the production of hydrogen and oxygen from water is known in the prior art and will not be described in detail here.

[0024] FIG. 2 shows a two-layer bipolar plate 1 according to FIG. 1. The cathode side 3 can be composed of thermoplastics, thermosetting plastics and/or elastomers, which has metal particles, metal carbide particles and/or metal nitride particles. The particles are composed in particular of titanium, niobium, silver, gold, platinum, iridium, titanium carbide, niobium carbide, titanium nitride and/or niobium nitride. The anode side 4 can be composed of thermoplastics, thermosetting plastics and/or elastomers, which has carbon filling particles. The carbon filling particles are composed in particular of carbon black, graphite, graphene, carbon fibers and/or carbon nanotubes, wherein the content of the carbon filling particles in the polymer material of the anode side 4 is at least 70 vol.%. The cathode side 3 and the anode side 4 are connected to one another via material connection. Since the bipolar plate 1 is shown in a simplified manner, the outwardly facing surface is not shown in a structured manner, although the outwardly facing surface may have structures, in particular recesses and protrusions, through which at least the water for electrolysis is supplied and guided.

[0025] FIG. 3 shows a three-layer bipolar plate 1 according to a second embodiment. In this case, a reinforcer 5 configured as a metal mesh or a metal strip is arranged between the cathode side 3 and the anode side 4. The cathode side 3 and the reinforcer 5 are connected to one another via material connection like the anode side 4 and the reinforcer 5. The three-layer bipolar plate 1 according to FIG. 3 otherwise corresponds to the two-layer bipolar plate 1 according to FIGs. 1 and 2.

LIST OF REFERENCE NUMERALS

[0026]

1	Bipolar plate
2	PEM electrolysis device
3	Cathode side of the bipolar plate
4	Anode side of the bipolar plate
5	Reinforcer
6.1	Battery
6.2	Battery
7.1	Transport layer
7.2	Transport layer
8.1	Catalytic layer
8.2	Catalytic layer
9.1	Membrane
9.2	Membrane
10	Cathode
11	Anode
12	Anode
13	Cathode
14	Anode side
15	Cathode side

Claims

1. A bipolar plate (1) for use in a PEM electrolysis device (3), wherein the bipolar plate (1) is composed of at least one polymer material, and has a cathode side (3) comprising carbon filling particles and an

anode side (4) comprising metal particles, metal carbide particles and/or metal nitride particles.

2. The bipolar plate (1) according to Claim 1, **characterized in that** the metal particles, metal carbide particles and metal nitride particles are selected from titanium, niobium, silver, gold, platinum, iridium, titanium carbide, niobium carbide, titanium nitride and niobium nitride.

3. The bipolar plate (1) according to Claim 1 or 2, **characterized in that** the carbon filling particles are selected from carbon black, graphite, graphene, carbon fibers and carbon nanotubes.

4. The bipolar plate (1) according to any one of the preceding claims, **characterized in that** the content of the carbon filling particles in the at least one polymer material is at least 70 vol.%.

5. The bipolar plate (1) according to any one of the preceding claims, **characterized in that** the bipolar plate (1) is composed at least partially of at least one thermoplastic selected from PP, PVF, PVDF, PTFE, PCTFE, ETFE, PA, PPA, PPS, LCP, PEEK, PC, PSU, PESU and PEI.

6. The bipolar plate (1) according to any one of the preceding claims, **characterized in that** the bipolar plate (1) is composed at least partially of at least one thermosetting plastic selected from phenolic resins, epoxy resins, melamine resins, unsaturated polyester resins, polyimides and polyamide-imides.

7. The bipolar plate (1) according to any one of the preceding claims, **characterized in that** the bipolar plate (1) is composed at least partially of at least one elastomer selected from FKM, FFKM, EPDM, CR, IIR, CSM, FVMQ.

8. The bipolar plate (1) according to any one of the preceding claims, **characterized in that** a reinforcer (5) is at least partially arranged between the cathode side (3) and the anode side (4).

9. The bipolar plate (1) according to Claim 8, **characterized in that** the reinforcer (5) is configured as a metal mesh or a metal strip.

10. A PEM electrolysis device (2) comprising the bipolar plate (1) according to any one of the preceding claims.

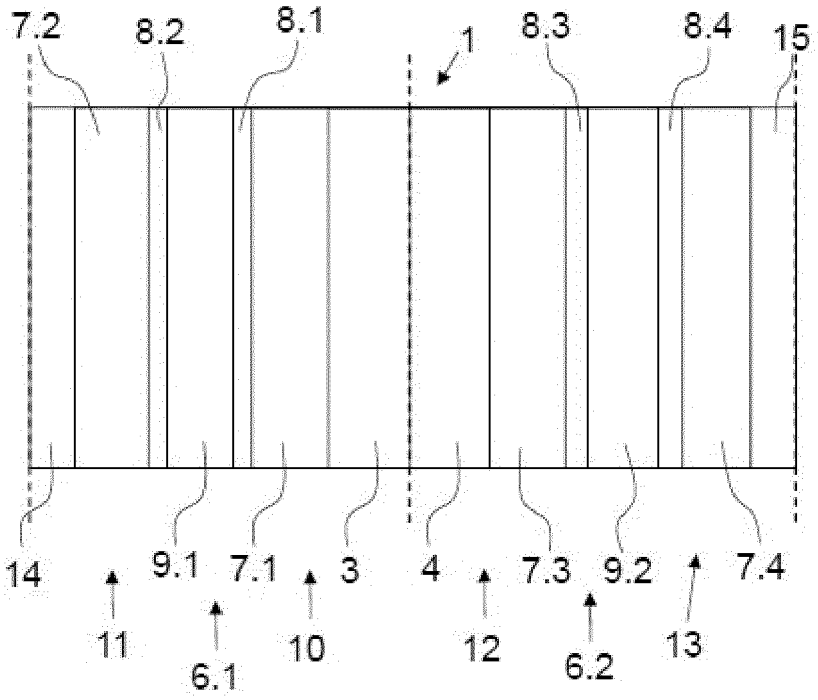

FIG. 1

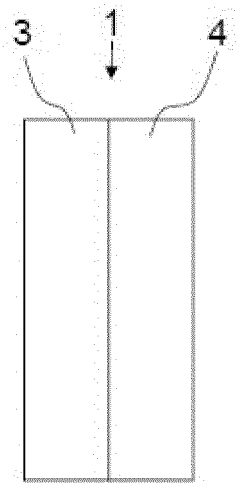

FIG. 2

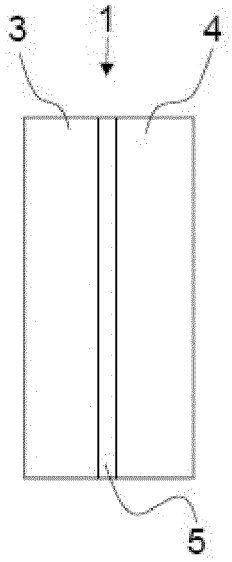

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2021/094997

A. CLASSIFICATION OF SUBJECT MATTER

C25B 9/19(2021.01)i

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)

C25B

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 practicable, search terms used)

CNTXT, CNKI, CNABS, DWPI, SIPOABS: 电解, 双极板, 高分子, 树脂, 复合, 碳, 金属, electrolytic, bipolar, plate, polymer, resin, composite, carbon, metal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 212770997 U (HUNAN FANGU NEW ENERGY TECHNOLOGY CO., LTD.) 23 March 2021 (2021-03-23) description, paragraphs 0013-0023, and figure 1	1-10
Y	CN 1591941 A (DALIAN INSTITUTE OF CHEMICAL PHYSICS, CHINESE ACADEMY OF SCIENCES) 09 March 2005 (2005-03-09) description, page 3, line 10-page 5, line 15	1-10
Y	CN 111041510 A (NEKSON POWER TECHNOLOGY CO., LTD.) 21 April 2020 (2020-04-21) description, paragraphs 0005-0015, and figures 1-2	8-9
A	US 2002001743 A1 (DAVIS, J. H.) 03 January 2002 (2002-01-03) entire document	1-10

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
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"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
12 January 2022	**23 February 2022**
Name and mailing address of the ISA/CN **China National Intellectual Property Administration (ISA/CN)** **No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088, China** Facsimile No. **(86-10)62019451**	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2021/094997

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 212770997 U	23 March 2021	None	
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Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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- DE 102014109321 A1 **[0003]**
- DE 102013207082 A1 **[0004]**