Claims

1. An electrochemical cell, comprising:

a proton conductor represented by $(Li, H)_{14-2x}Zn_{1+x}(GeO_4)_4$ where a portion of lithium ions of $Li_{14-2x}Zn_{1+x}(GeO_4)_4$ where x is a number equal to or more than 0 is substituted with protons, the proton conductor having electric conductivity of 0.01 S/cm or more at 300°C;

an anode provided on one side of the proton conductor;

a cathode provided on another side of the proton conductor;

a first separator provided on an anode side of the proton conductor to define an anode chamber; and

a second separator provided on a cathode side of the proton conductor to define a cathode chamber.

2. The electrochemical cell according to claim 1, further comprising a temperature adjustor configured to maintain a temperature of the proton conductor between 200°C and 600°C inclusive.

3. The electrochemical cell according to claim 1 or 2, wherein the x is 0.

4. The electrochemical cell according to any one of claims 1 to 3, wherein 40% to 70% inclusive of movable lithium ions contained in $Li_{14-2x}Zn_{1+x}(GeO_4)_4$ are substituted with the protons.

5. The electrochemical cell according to any one of claims 1 to 3, wherein 50% to 60% inclusive of movable lithium ions contained in $Li_{14-2x}Zn_{1+x}(GeO_4)_4$ are substituted with the protons.

6. The electrochemical cell according to any one of claims 1 to 5, comprising a plurality of cells each including the proton conductor, the anode, the cathode, the first separator, and the second separator,

wherein the first separator of one of the plurality of cells is in contact with the second separator of another of the plurality of cells so as to exchange heat.

7. The electrochemical cell according to any one of claims 1 to 6, wherein hydrogen is supplied to the anode chamber,

air is supplied to the cathode chamber, and

an electromotive force is generated between the anode and the cathode, and the electrochemical cell functions as a hydrogen-oxygen fuel cell.

8. The electrochemical cell according to any one of claims 1 to 6, wherein a hydrogen-containing compound containing hydrogen is supplied to the anode chamber,

air is supplied to the cathode chamber,

a catalyst layer containing a catalyst configured to generate a hydrogen gas from the hydrogen-containing compound is provided in the anode chamber, and

an electromotive force is generated between the anode and the cathode, and the electrochemical cell functions as a hydrogen-oxygen fuel cell.

9. The electrochemical cell according to claim 8, wherein the hydrogen-containing compound is an organic hydride compound where an aromatic having 1-3 rings is hydrogenated.

10. The electrochemical cell according to claim 8, wherein the hydrogen-containing compound includes at least one selected from a group consisting of methylcyclohexane, cyclohexane, trimethylcyclohexane, decalin, benzyltoluene, and dibenzotriol.

11. The electrochemical cell according to claim 8, wherein the hydrogen-containing compound includes at least one selected from a group consisting of ammonia, formic acid, methanol, and dimethyl ether.

12. The electrochemical cell according to any one of claims 8 to 11, wherein the catalyst is a dehydrogenation catalyst including an alumina carrier and platinum carried by the alumina carrier, and

an average particle diameter of the platinum is 2 nm or less.

13. The electrochemical cell according to any one of claims 1 to 6, wherein water vapor is supplied to the anode chamber,

a DC power supply is connected between the anode and the cathode, and

the electrochemical cell functions as an electrolytic cell to form hydrogen at the cathode.

14. A power generation method using the electrochemical cell according to any one of claims 1 to 6, comprising:

supplying hydrogen to the anode chamber;

supplying air to the cathode chamber; and

maintaining a temperature of the proton conductor between 200°C and 600°C inclusive.

15. A power generation method using the electrochemical cell according to any one of claims 1 to 6, comprising:

providing a catalyst layer in the anode chamber, the catalyst layer being configured to generate a hydrogen gas from a hydrogen-containing compound;

supplying the hydrogen-containing compound to the anode chamber;

supplying air to the cathode chamber; and

maintaining a temperature of the proton conductor between 200°C and 600°C inclusive.

16. The power generation method according to claim 15, wherein the hydrogen-containing compound is an organic hydride compound where an aromatic having 1-3 rings is hydrogenated.

17. The power generation method according to claim 15, wherein the hydrogen-containing compound includes at least one selected from a group consisting of methylcyclohexane, cyclohexane, trimethylcyclohexane, decalin, benzyltoluene, and dibenzotriol.

18. The power generation method according to claim 15, wherein the hydrogen-containing compound includes at least one selected from a group consisting of ammonia, formic acid, methanol, and dimethyl ether.

19. The power generation method according to any one of claims 15 to 18, wherein the catalyst layer includes a dehydrogenation catalyst including an alumina carrier and platinum carried by the alumina carrier, and

an average particle diameter of the platinum is 2 nm or less.

20. A manufacturing method of a hydrogen gas by electrolysis using the electrochemical cell according to any one of claims 1 to 6, comprising:

supplying water vapor to the anode chamber;

maintaining a temperature of the proton conductor between 200°C and 600°C inclusive; and

applying a DC voltage between the anode and the cathode and generating a hydrogen gas at the cathode.

21. A manufacturing method of a hydrogen gas by electrolysis using the electrochemical cell according to any one of claims 1 to 6, comprising:

providing a catalyst in the anode chamber;

supplying the anode chamber with ammonia or at least one hydrocarbon selected from a group including methylcyclohexane, formic acid, methanol, and dimethyl ether;

maintaining a temperature of the proton conductor between 200°C and 600°C inclusive;

applying a DC voltage between the anode and the cathode; and

generating the protons from the ammonia or the hydrocarbon by the catalyst in the anode chamber, moving the protons to the cathode through the proton conductor, and generating a hydrogen gas at the cathode.

22. A manufacturing method of a hydrogen gas by electrolysis using the electrochemical cell according to any one of claims 1 to 6, comprising:

performing the electrolysis in a pressurized condition.