CLAIMS

1. A catalytic membrane reactor, comprising means for carrying out the electrochemical pumping of hydrogen, said membrane comprising:

   - Two electrodes, an anode (3) and a cathode (1), sandwiching an electrolyte (2); both anode (3) and cathode (1) are electrically conductive; said electrolyte (2) is non electrically conductive and forms a layer which is selective to protons (e.g. do not transport neither reactants nor products);
   - A suitable chemical catalyst (4), deposited on the anode (3), or in the interface between the anode (3) and the electrolyte (2);
   - Said anode (3) containing an electrocatalyst for the hydrogen oxidation, impregnating the anode (3) or deposited in the interface between the anode (3) and the electrolyte (2);
   - Said cathode (1) containing an electrocatalyst for hydrogen reduction, impregnating the cathode (1) or deposited in the interface between the electrolyte (2) and the cathode (1).

2. A catalytic membrane reactor as claimed in claim 1, wherein said reactor can further comprise a power supply that applies an electrical potential difference between both electrodes.

3. A catalytic membrane reactor as claimed in claim 1, wherein said reactor further comprises a system for feeding to the cathode a gaseous flow containing oxygen.

4. A catalytic membrane reactor as claimed in any one of prior claims, wherein said chemical catalyst (4) is present under a nanoparticle form.

5. A catalytic membrane reactor as claimed in any one of claims 1 to 4, wherein said chemical catalyst (4) is decorated with the platinum or palladium electrocatalyst, both under a nanoparticle form.

6. A catalytic membrane reactor as claimed in any one of claims 1 to 5, wherein said chemical catalyst (4) is under a nanoparticle form and is deposited on the anode.

7. A catalytic membrane reactor as claimed in any one of claims 1 to 6, wherein said catalyst is deposited between the anode (3) and the electrolyte (2), said anode being porous.

8. A catalytic membrane reactor as claimed in any one of claims 1 to 7, wherein said anode (3) consists of palladium or a palladium and silver alloy.

9. A catalytic membrane reactor as claimed in any one of claims 1 to 8, wherein said cathode (1) consists of palladium or porous palladium layer.

10. A catalytic membrane reactor as claimed in any one of claims 1 to 9, wherein the composite membrane is supported on a ceramics or metallic porous membrane.

11. A catalytic membrane reactor as claimed in any one of claims 1 to 10, wherein the electrolyte (2) consists of a phosphoric acid-doped polybenzimidazole membrane, and the working temperature range goes from 120°C to 200°C.

12. A catalytic membrane reactor as claimed in any one of claims 1 to 10, wherein the working temperatures go to 600°C.

13. A catalytic membrane reactor as claimed in any one of claims 1 to 12, wherein the electrolyte (2) is of yttrium-doped zirconium phosphate (YSZ) and the working temperature range goes from 120°C to 600°C.

14. A catalytic membrane reactor with membrane, comprising means for carrying out the electrochemical pumping of oxygen equipped with a composite membrane, said membrane comprising:

- Two electrodes, an anode (3) and a cathode (1) sandwiching an electrolyte (2); both anode (3) and

cathode (1) are electrically conductive; and said electrolyte (2) is non electrically conductive and is selective to anionic oxygen;

- A suitable chemical catalyst (4), which is present under a nanoparticle form and is impregnated in the anode (3);
- At last one gas feeder in the cathode (1) side, said fed gas mixture containing oxygen;
- The anode (3) is impregnated, or it contains an electrocatalyst for the oxygen oxidation, deposited in the interface anode (3) / electrolyte (2);
- The cathode (1) is impregnated, or it contains an electrocatalyst deposited in the interface between the electrolyte (2) and the cathode (1).

15. The catalytic membrane reactor as claimed in prior claim, wherein it further includes a power supply that applies an electrical potential difference between both electrodes.

16. The catalytic membrane reactor as claimed in claims 14-15, wherein said composite membrane is a typical solid oxide fuel cell (SOFC) membrane.

17. The catalytic membrane reactor as claimed in any one of claims 14 to 16, wherein the working temperature ranging from 500ºC to 1000ºC.

18. The catalytic membrane reactor as claimed in any one of claims 14 to 16, wherein the fed gas is air.

19. The catalytic membrane reactor as claimed in any one of prior claims, wherein it comprises a bundle of tubular composite membranes.

20. A method for the direct amination reaction of hydrocarbons, characterized in that it consists of the following steps:

- The use of a catalytic membrane reactor, as the one described in any one of prior claims, at the operation temperature and pressure;
- The feeding of a hydrocarbon and ammonia flow in the presence of a suitable catalyst;
- The removal of the hydrogen formed in said reaction, by pumping hydrogen or oxygen, so that said membrane should be able to enable the electrochemical pumping of hydrogen formed in the reaction medium or the electrochemical pumping of oxygen to the chemical catalyst surface for oxidizing the hydrogen formed.

21. A method for the direct amination, as claimed in prior claim, wherein said hydrocarbon and ammonia feed flows are fed in stoichiometric proportions.

22. A method for the direct amination, as claimed in claims 20 to 21, wherein the ammonia is fed above the stoichiometric proportion compared to the hydrocarbon feed.

23. A method for the direct amination, as claimed in claims 20 to 22, wherein said hydrocarbon is benzene and the reaction product is aniline.

CLAIMS

1. A catalytic membrane reactor, comprising means for carrying out the electrochemical pumping of hydrogen, said membrane comprising:

   - two electrodes, an anode (3) and a cathode (1), sandwiching an electrolyte (2); both anode (3) and cathode (1) are electrically conductive; said electrolyte (2) is non electrically conductive and forms a layer which is selective to protons (e.g. do not transport neither reactants nor products);
   - a suitable chemical catalyst (4), deposited on the anode (3), or in the interface between the anode (3) and the electrolyte (2);
   - said anode (3) containing an electrocatalyst for the hydrogen oxidation, impregnating the anode (3) or deposited in the interface between the anode (3) and the electrolyte (2);
   - said cathode (1) containing an electrocatalyst for hydrogen reduction, impregnating the cathode (1) or deposited in the interface between the electrolyte (2) and the cathode (1).

2. A catalytic membrane reactor as claimed in claim 1, wherein said reactor further comprises a system for feeding to the cathode a gaseous flow containing oxygen.

3. A catalytic membrane reactor as claimed in claim 1 or claim 2, wherein said chemical catalyst (4) is present under a nanoparticle form.

4. A catalytic membrane reactor as claimed in any one of claims 1 to 3, wherein said chemical catalyst (4) is decorated with the platinum or palladium electrocatalyst, both under a nanoparticle form.

5. A catalytic membrane reactor as claimed in any one of claims 1 to 4, wherein said chemical catalyst (4) is under a nanoparticle form and is deposited on the anode.

6. A catalytic membrane reactor as claimed in any one of claims 1 to 5, wherein said catalyst is deposited between the anode (3) and the electrolyte (2), said anode being porous.

7. A catalytic membrane reactor as claimed in any one of claims 1 to 6, wherein the working temperatures go to 600°C.

8. A catalytic membrane reactor with membrane, comprising means for carrying out the electrochemical pumping of oxygen equipped with a composite membrane, said membrane comprising:

- two electrodes, an anode (3) and a cathode (1) sandwiching an electrolyte (2); both anode (3) and cathode (1) are electrically conductive; and said electrolyte (2) is non electrically conductive and is selective to anionic oxygen;
- a suitable chemical catalyst (4), which is present under a nanoparticle form and is impregnated in the anode (3);
- a-t least one gas feeder in the cathode (1) side, said fed gas mixture containing oxygen;
- the anode (3) is impregnated, or it contains an electrocatalyst for the oxygen oxidation, deposited in the interface anode (3) / electrolyte (2);
- the cathode (1) is impregnated, or it contains an electrocatalyst deposited in the interface between the electrolyte (2) and the cathode (1).

9. The catalytic membrane reactor as claimed in claim 8, wherein it further includes a power supply that applies an electrical potential difference between both electrodes.

10. The catalytic membrane reactor as claimed in claim 8 or claim 9, wherein the working temperature ranging from 500°C to 1000°C.

11. The catalytic membrane reactor as claimed in any one

of claims 8-10, wherein it comprises a bundle of tubular composite membranes.

12. A method for the direct amination reaction of hydrocarbons, characterized in that it consists of the following steps:

- the use of a catalytic membrane reactor, as the one described in any one of prior claims, at the operation temperature and pressure;
- the feeding of a hydrocarbon and ammonia flow in the presence of a suitable catalyst;
- the removal of the hydrogen formed in said reaction, by pumping hydrogen or oxygen, so that said membrane should be able to enable the electrochemical pumping of hydrogen formed in the reaction medium or the electrochemical pumping of oxygen to the chemical catalyst surface for oxidizing the hydrogen formed.

13. A method as claimed in claim 12, wherein said hydrocarbon and ammonia feed flows are fed in stoichiometric proportions.

14. A method as claimed in claim 12 or claim 13, wherein the ammonia is fed above the stoichiometric proportion compared to the hydrocarbon feed.

15. A method as claimed in any one of claims 12 to 14, wherein said hydrocarbon is benzene and the reaction product is aniline.