Patent Claims

1. A method to convert H_2 and CO_2 into methane by methanogenic microorganisms in a bioreactor in the methane production phase comprising the steps:

i. culturing the methanogenic microorganisms in a suitable liquid culture medium comprising minerals in a continuous process;

ii. culturing the methanogenic microorganisms under cell retention conditions;

iii. contacting the methanogenic microorganisms with at least one feeding gas comprising CO_2 and H_2;

iv. continuously removing metabolic water in the culture medium from the bioreactor;

v. collecting methane or a methane enriched gas composition,

wherein the culturing of the methanogenic organisms comprises a cell growth phase prior to the methane production phase, comprising the steps of:

- controlling and regulating the concentration of a nitrogen source within the culture medium by supplying the nitrogen source to the culture medium in a range of 0.2 moL/L/day to 0.005 moL/L/day, preferably of 0.02 moL/L/day to

0.01 moL/L/day to enable cell division and cell growth of the methanogenic microorganisms;

- culturing the methanogenic microorganisms up to a density in the culture medium measured as OD_{610} being at least 1, 9 up to 200 or at least 20 up to 120, preferably at least 60 up to 100 and corresponding to a dry weight of the microorganisms in the culture of at least 0.5 g/L and up to 50 g/L or at least 6.5 g/L and up to 31.3 g/L or at least 18.3 g/L and up to 26.1 g/L respectively.

2. The method according claim 1, wherein step i. comprises at least one cycle of culturing the methanogenic microorganisms under:

- a first phase in a continuous process in a suitable liquid, minerals containing, culture medium comprising a reduced supply of at least one mineral; followed by
- a second phase, characterized by refreshing the culture medium;
- optional followed by a third phase in a continuous process comprising a reduced supply of at least one mineral.

3. The method according to any of claims 1 or 2, wherein step ii. comprises at least one cycle of culturing the methanogenic microorganisms under:

- a fourth phase under cell retention conditions; followed by
- a fifth phase, characterized by culturing the cells under no cell retention conditions;
- optional followed by a sixth phase under cell retention conditions.

4. The method according to any of the previous claims, wherein the step of culturing the methanogenic organisms comprise:

- controlling and reducing the supply of a nitrogen source in the methane production phase, to receive a nitrogen source concentration in the culture medium, in an amount of 0.2 moL/L/day to 0 moL/L/day or of 0.02 moL/L/day to 0.005 moL/L/day preferably between 0.11 moL/L/day 0.005 moL/L/day.

5. The method according to any of the previous claims, wherein the step of culturing the methanogenic organisms further comprise:

- providing a sulfide source, preferably in the form of Na_2S in the culture medium;
- keeping the culture conditions anaerobic or facultatively anaerobic;
- optionally stirring the culture;
- keeping the temperatures in a range from 32°C and 85°C.

6. The method according to any of the previous claims, wherein the nitrogen source is selected from ammonium compounds, preferably in the form of NH_4OH or NH_4Cl or combinations of the aforementioned.

7. The method according to any of the previous claims, further comprising the step of setting an initial pH value to be at a given value of below pH 9, below pH 8 or at pH 7and subsequent continuously controlling the pH value.

8. The method according to any of the previous claims, wherein the removing of the metabolic water comprises the step of filtrating excess water away from the culture medium and/or comprises the step of evaporating excess water from the culture medium.

9. The method according to claim 8, wherein the step of filtrating excess water away from the culture medium is performed by reverse osmosis using at least one semipermeable membrane for water in contact with the culture medium.

10. The method according to claim 8, wherein the step of filtrating excess water away comprises the step of:

- removing fractions of cell-free culture medium from the bioreactor by filtration through at least one porous membrane in contact with the culture medium, preferably having a pore size of 0.4 to 0.1 μm, particularly preferably of 0.3 μm; and

- optionally, subsequently concentrating the minerals from the removed culture medium preferably by at least one further filtration step, e.g. nanofiltration, ultrafiltration and/or by at least one distillation step; and

- optionally, at least partially recycling the concentrated minerals back to the bioreactor.

11. The method according to any of the previous claims, further comprising the step of controlling and optionally regulating the concentration of at least one entity of the minerals in the culture medium by additional adding of minerals.

12. The method according to any of the previous claims, wherein at least one methanogenic microorganism is selected from the group of Archaea or archaebacteria comprising of *Methanobacterium, Methanobrevibacter, Methanothermobacter, Methanococcus, Methanosarcina, Methanopyrus* or mixtures thereof.

13. The method according to any of the previous claims, wherein within the methane production phase under cell retention conditions at least 60% and preferably more than 80% of the overall methanogenic microorganisms in the bioreactor have a ratio of length to width of 5:1 to 3:1, preferably from 4:1 to 3:1, particularly preferably 3:1.