Energy Conversion of Carbon Dioxide Using Methanogen

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The underground disposal technology of carbon dioxide is a method of reducing atmospheric emissions of carbon dioxide for preventing global warming. In this technology, carbon dioxide is separated from atmosphere, and stored in some reservoirs such as aquifers, depleted gas and oil reservoirs. However, carbon dioxide is only stored in a reservoir up on semipermanently, and is not considered especially about its reuse.

We are planning to build up a recycle system of carbon dioxide as energy resources, by changing carbon dioxide into methane in a reservoir using methanogens. Methanogens are classified into archaea and generate methane in an anaerobic condition. Methanogen usually use organic acids, methylamines and alcohols as substrates, and generate methane and carbon dioxide. However, some methanogens can generate methane using carbon dioxide and hydrogen in autotrophically, and generate no carbon dioxide.

In this work we used Metanococcus maripaludis JCM10011 as methanogen. which belongs to hydrogentrophic methanogen, one of oceanic microorganisms, the optimum temperature and pH value are 35 - 40 degrees and 6.5 - 8.0, respectively. The microorganism was grown under strict anaerobic conditions in 125 mL vials (containing 30 mL of medium) closed with butyl rubber stoppers and aluminum seals in the JCM228 medium, which composition was follows : General salts solution, 500mL; Trace minerals solution, 10.0mL; Iron stock solution, 5.0mL; NaCl, 22.0g; KH2PO4, 0.14g; Sodium acetate, 1.36g; Bacto yeast extract 2.0g; Resazurin, 1.0mg; NaHCO3, 5.0g; L-Cystein HCl H2O, 0.5g; Na2S 9H2O, 0.5g; Distilled water, 485.0mL: General salts solution: MgCl2 6H2O, 5.5g; MgSO4 7H2O, 6.9g; NH4Cl, 1.0g; KCl, 0.67g, CaCl2 2H2O, 0.28g, Trace minerals solution: Nitrilotriacetic acid, 1.5g; Fe(NH4)2(SO4)2 6H2O, 0.2g, NaSeO3, 0.2g; Na2MoO4 2H2O, 0.1g; Na2WO4 2H2O, 1.0g; MnSO4 xH2O, 0.1g; ZnSO4 7H2O, 0.1g; NiCl2 6H2O, 0.025g; CuSO4 5H2O, 0.01g; Distilled water, 1.0 L: Iron stock solution: Fe(NH4)2(SO4)2 6H2O, 0.2g; Distilled water, 100mL. The headspace was subsequently flushed with oxygen-free H2-CO2 (80:20). The vials were inoculated and incubated at 37 degrees without agitation in a incubator. Samples were withdrawn from the headspace and the concentrations of methane and hydrogen were measured by a gas chromatograph with a thermal conductivity detector at very predetermined times.

At one day after the experiment started, hydrogen concentration decreased and methane concentration increased. It was confirmed that the methane generation by M. maripaludis. Hydrogen concentration decreased from 0.036 mol/mL to 0.01 mol/mL for 15 days incubation. Then, 0.006 mol/mL of methane was generated. The ratio of methane generation to hydrogen comsumption was about 1 : 4. This fact was suggested that the methane was generated as following reaction; 4H2+CO2 = CH4+2H2O.

The next experiment was carried out using the modified JCM228 medium without sodium acetate

and Bacto yeast extract, because it was considered that there are little nutrients contained the growth medium at the reservoir environment. In this experiment, the generated methane concentration for 15 days was 0.0015 mol/mL, 1/4 times smaller than that using compete JCM228 medium containing yeast extract. M. maripaludis obtains usually energy by methane generation using carbon dioxide and hydrogen, and uses no organic conpounds. However, the activity of M. maripaludis reduced by lacking some organic in the growth medium. This fact suggests that it is very important to examine what kinds of and how much amount of chemical species there are in the underground reservoir for the methane generation.