L215-003 **Room: 303** **Time: May 21 11:15-11:30**

Feasibility study of methanogenic bio-process from geologically sequestered carbon dioxide

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Carbon dioxide capture and storage (CCS) is one of the feasible technological options for reducing net CO_2 emissions to the atmosphere. However, further studies on uncertainty parameter such as detention period and leakage CO_2 are required toward the practical use. In order to establish sustainable carbon cycle, development of carbon conversion processes capable of converting CO2 stored in subsurface by CCS into reusable sources of energy is required. Regeneration of methane gas pool using microbial processes is thought to be one of the technical options addressing for this issue. Although biological CH_4 production were observed in oil fields under various environmental conditions, few microbial CH_4 production under CCS conditions have been proposed. Thus many uncertainties remain regarding technological feasibility of the microbial CH_4 regeneration for industrial applications. The objective of this study is exploring the technological feasibility of microbial CH_4 regeneration in subsurface environments after CCS implementation. In order to investigate the feasibility of microbial CH_4 regeneration from CO^2 derived from CCS in subsurface, effect of physicochemical and/or nutritional factors on CH_4production rate were evaluated under the virtual CCS conditions, such as high-CO_2, low pH, and nutrient-depleted employing formation waters obtained from petroleum reservoir as growth medium. Moreover, total productivity was investigated compared with CH_4 production rate under standard conditions. We used thermophilic hydrogenotrophic methanogens, *Methanothermobacter thermautotrophicus* and *Methanothermococcus thermolithotrophicus* under low pH, high-CO_2 ratio and nutrient limitations as subsurface conditions after CCS operation. As most ideal environment for methanogen, we set the standard conditions ; H_2-CO_2 ratio 80-20, standard media (ATCC 1439 medium for *M. thermolithotrophicus*, ATCC 2133 for *M. thermautotrophicus*) and pH 7.5. In comparison, the virtual CCS conditions were set; H_2-CO_2 ratio 20-80, formation water and pH 5.5. As a result, *M. thermolithotrophicus* was not able to produce CH_4 under virtual CCS conditions, whereas *M. thermautotrophicus* retained its metabolic activity. Employment of formation waters as growth medium resulted in extremely lower CH^4productivities of *M. thermolithotrophicus* compared to those under standard conditions. *M. thermautotrophicus* was able to produce CH_4 under virtual CCS conditions such as H_2-CO_2 ratio 20-80, formation water and pH 5.5. The CH_4 production rate, however, dropped down to about 3% of the standard conditions. It was caused by both low pH and formation water as growth medium. Finally, we estimated the above CH_4 productivity. It was converted to the rate which could produce annual natural gas production in Japan over 8 years.