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Activities of the Core

Sep 7, 2022	The 74th HU-ACE Steering Committee Meeting
Sep 9, 2022	Prof. Kindaichi gave a keynote speech titled "Toward High Efficient Operation of Geothermal Heat Utilization in Warm Regions" at the 2022 JSRAE Annual Conference.
Sep 21~, 2022	Prof. Ichikawa is in charge of the online next-generation energy course Ammonia (Environmental Business Online).
Sep 22, 2022	The 106th HU-ACE Seminar (co-organized)

Feasibility study related to ground source heat pumps by NEDO project

A NEDO project named "Feasibility study on an air conditioning system with double water tanks for thermal energy storage" was launched in August 2022. This system aims to improve the cost effectiveness of ground source heat pumps through the by application of two kinds of thermal energy storage: one being "heat source water storage" for hybrid use of different renewable heats and reduction of pumping power, another being "chilled/warm water storage" for adjustment of renewable power supply and heat demand in the building side. This system can function as an alternative to conventional air conditioning systems in existing buildings, such as in Hiroshima University. Through this study, we hope to contribute to the decarbonization of the campus thorough the reduction of energy consumption and CO_2 emissions in the building side.

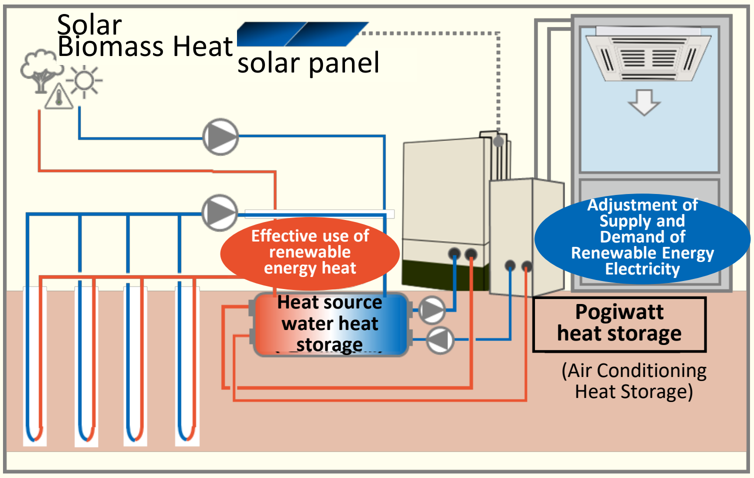

Fig. Conceptual diagram of double heat storage air conditioning system

研究相談、共同研究など大歓迎です！

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Research Topics No. 35

Is hydrogen a hindrance?

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Research fields: Fermentation technology, Biochemical engineering

Keywords: Anaerobic microorganisms, Synthetic gas, Carbon recycling

Abstract

Background

When sugars are fermented by yeast, carbon dioxide (CO_2) is produced in addition to ethanol. For example, 4 carbon atoms are used for ethanol and the remaining 2 carbons atoms are exhausted as CO_2 from the 6 carbons atoms contained in one molecule of hexose. If this CO_2 can be fermented into ethanol, theoretically, three molecules of ethanol can be produced from one molecule of glucose. However, additional reduction power is required to convert them. In our laboratory, we constructed a recombinant strain of the thermophilic homoacetogen, *Moorella thermoacetica,* which produces acetic acid from sugar and hydrogen (H_2) and CO_2, for bulk chemical production such as ethanol (1) and acetone (2). By culturing these strains in the coexistence of sugar and hydrogen (renewable hydrogen in the future), we are studying whether CO_2, which cannot be converted by sugar alone, can be converted into the desired bulk chemical product (3).

Research content

M. thermoacetica, which was genetically modified to produce ethanol or acetone and changing the production capacity of acetic acid, was cultivated with sugar and H_2. In the case of non-recombinant strains and ethanol-producing strains that retain the ability to produce acetic acid, the growth did not change compared to the case where H_2 was not added, and an improvement in product yield was observed. In the case of acetone-producing strains that retain the acetic acid-producing pathway, improvement in acetone yield was also confirmed. This suggests that the co-cultivation of sugar and H_2 can convert all carbons immobilized on the sugar into the target product.

On the other hand, in the ethanol-producing strain where the acetic acid-producing pathway was knocked out, the ethanol yield was slightly improved by the addition of H_2, but the growth was significantly inhibited. Metabolome analysis revealed that the intracellular NADH level of the non-acetate ethanol-producing strain was significantly increased by the addition of H_2. The growth was restored by the addition of dimethyl sulfoxide, an electron acceptor that lowers NADH levels. Furthermore, this strain produced H_2 during sugar fermentation without H_2 addition, but the addition of H_2 inhibited H_2 production. From these results, it was suggested that the growth inhibition by H_2 was caused by the functional deterioration of the reversible hydrogenase that contributes to the stabilization of the intracellular oxidation-reduction balance.

Conclusion and opinion

This research demonstrates a possibility of the realization of "complete carbon recovery fermentation" that converts all sugar carbon into the target substance. On the other hand, like the malfunction of the oxidation-reduction balance maintenance system in the study, it works when producing the original metabolites of microorganisms, but it often does not work when trying to produce a large number of other products. With the development of gene recombination technology, it has become extremely easy to give new metabolic pathways to microorganisms and to eliminate unnecessary pathways. On the other hand, the understanding of the various intracellular environment stabilization systems acquired over the long evolutionary process is not sufficient. Even cultures that simply mix sugar and hydrogen have a lot of problems, thus comprehensive biotechnology research including basic research is needed.

References

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(3) S. Kobayashi, et al., Frontiers in Microbiology. 13 (2022).