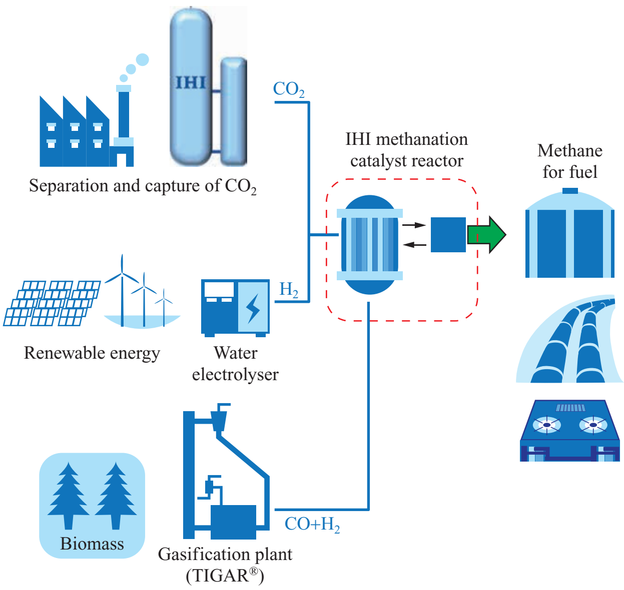
Converting Greenhouse Gas CO_2 into High Value-Added Materials

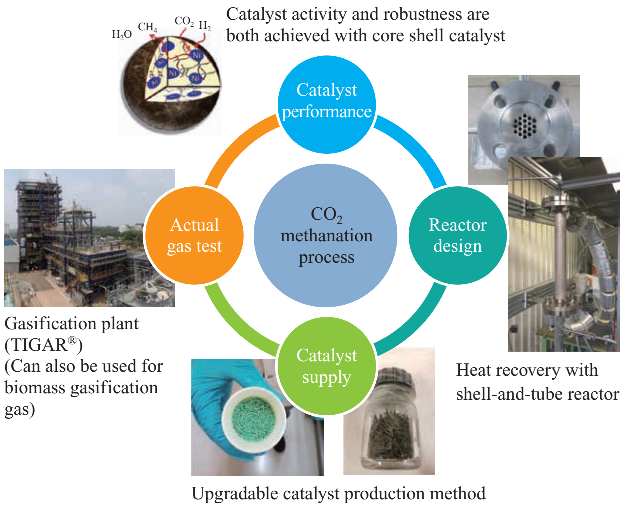
CO_2 conversion technology: 'Methanation'

In order to realize a carbon recycling society, active use of CO_2 is required. The IHI Group is working to develop methanation technology, which is expected to provide a means of converting CO_2 into high value-added materials. Further conversion to chemical feedstock is now within reach.

ENDO Takumi
Basic Design Department,
Engineering Center,
Carbon Solution Business Unit,
Resources, Energy & Environment Business Area,
IHI Corporation



CO_2 capture and utilization flowchart



Methanation development process

Expectations for methanation

Both in Japan and overseas, strong interest and high expectations are being directed at carbon recycling technologies that aim to reduce carbon dioxide (CO_2) emissions. Amongst these, methanation technology, which is used to convert CO_2 into the fuel methane (CH_4), occupies a leading position. Methane gas is the main component of current city gas. The methane gas produced by methanation can be compressed into the installed pipeline to be used with existing infrastructure, such as household gas stoves, without significant modifications. Methanation, if achieved, will make it possible to reduce CO_2 emissions over wide areas where city gas is used, without modifications or additional equipment on the user side.

Since 2011, the IHI Group has been working to develop methanation technology that uses the carbon monoxide (CO) contained in coal gasification gas, and, by applying this technology to CO_2, is working to put the methane gas production process into practical use.

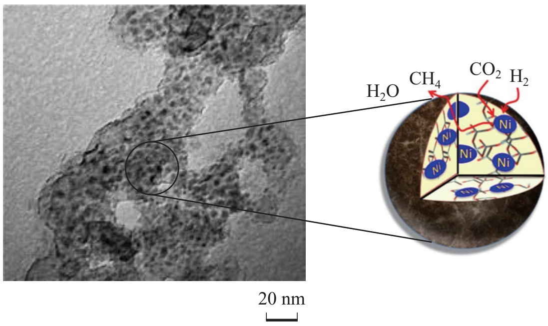
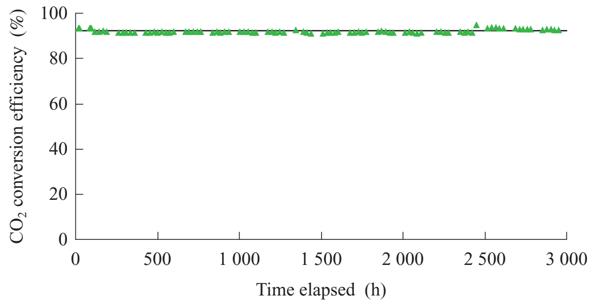


Photo and schematic of catalyst developed by IHI-ICES
(reference: https://doi.org/10.1016/j.cattod.2017.03.003)



Stability of CO_2 methanation catalyst

Key to methanation: Catalyst technology

A key to this process is the catalyst used to accelerate the methanation reaction. Working jointly with the Institute of Chemical and Engineering Sciences (ICES), which is part of Singapore's Agency for Science, Technology and Research (A*STAR), the IHI Group has developed a highly active, long-life catalyst. This catalyst has a structure called a core shell, in which a large number of active sites consisting of nickel metal are arranged finely and uniformly in a porous matrix with a three-dimensional structure, thereby achieving high conversion efficiency.

A common cause of degradation in catalyst performance is a phenomenon in which the active sites aggregate, resulting in reduction of the active surface area (sintering). However, the three-dimensional structure keeps the active sites appropriately separated, so that aggregation cannot readily occur. In addition, catalyst performance also degrades if the catalyst surface is covered with inert material (poisoning), although this can be prevented by appropriate pretreatment of the raw material in the exhaust gas. In fact, we confirmed that our catalyst operated very stably during 3 000 hours of operational evaluation, without sharp catalyst deterioration. Through further accelerated degradation testing, we plan to develop a catalyst that has higher conversion efficiency and a longer life.

Since the methanation reaction is an exothermic reaction, the catalyst in the reactor could become hot due to its own heat of reaction. If the catalyst becomes excessively high temperature, then conversion efficiency decreases, or the above-mentioned sintering occurs, resulting in reduced catalyst life. Therefore, especially when increasing the size of the reactor, it must be designed to have a uniform temperature environment, and this is an area in which the knowledge of chemical reactor design hitherto accumulated by the IHI Group can be effectively utilized.

We are developing systems in which this reactor heat is actively used. Heat is often required in the raw material preparation processes for methanation (e.g., the CO_2 capture process and H_2 purification process) and methane purification process, etc. Focusing on this high affinity, we are developing the integration processes that can make maximum use of recovered heat.

Based on the results of the laboratory-scale tests conducted in Singapore and IHI Yokohama Works, we are working on a demonstration test for further evaluation of the catalyst performance at a pilot plant in the Soma IHI Green Energy Center (SIGC).

Using this technology, methane is produced artificially, and its cost is therefore likely to be higher than that of methane derived from fossil resources in the natural world. In addition to improving efficiency and extending the life of the catalyst, we can enhance economic competitiveness by finding the optimum combination with other auxiliary equipment such as the CO_2 capture facility and hydrogen (raw material) production facility, which are located upstream of the catalyst.

Application to chemical feedstock

In addition to CO_2 conversion technology that uses CO_2 as an alternative to fossil fuels, we have launched development of a catalyst that converts CO_2 into olefin, which serves as a raw material in the chemical industry. Olefin is used as a raw material for plastic, and most of it is produced from crude oil.

We aim to produce olefin from the CO_2 in exhaust gas, etc. When burned (thermally recycled), the plastic made from this CO_2-derived olefin does not substantively increase the amount of CO_2 in the atmosphere. Hence, manufacture of this plastic allows recycling of CO_2.

The IHI Group continue to develop technologies that convert CO_2, which often carries a negative connotation, into fuels and materials that are rich in value, with the aim of realizing a carbon recycling society.

Inquiries:
Basic Design Department,
Engineering Center,
Carbon Solution Business Unit,
Resources, Energy & Environment Business Area,
IHI Corporation
Phone: +81-3-6204-7525
https://www.ihi.co.jp/en