

4A4. Dimethyl Ether Production Technology (DME)

Research and development: DME Development Co., Ltd., JFE Holdings Co., Ltd., Taiyo Nippon Sanso Corporation, Toyota Tsusho Corp., Hitachi Ltd., Marubeni Corp., Idemitsu Kosan Co., Ltd., INPEX Corporation, TOTAL S.A. (France), LNG Japan Co., Ltd., and Japan Petroleum Exploration Co., Ltd. (JAPEX).

Project type: National Grant project of "Development of Technology for Environmental Load Reducing Fuel Conversion" of the Agency for Natural Resources and Energy of the Ministry of Economy, Trade and Industry

Period: 2002-2006 (5 years)

Technology overview

1. Background and process overview

Dimethyl ether (DME) is a clean energy source and as it generates no sulfur oxide or soot during combustion its environmental impact is low. Owing to its non-toxicity and easy liquefaction properties, DME is easy to handle and therefore can be used as a domestic-sector fuel (substitute for LPG), transportation fuel (diesel vehicles, fuel cell vehicles), power plant fuel (thermal plants, cogeneration plants, stationary fuel cells), and as a raw material for chemical products. Currently DME is

produced by dehydrating methanol. Approximately ten thousand tons per year are produced in Japan, and 150 thousand tons per year worldwide. DME's main use is as a spray propellant. Given the above-described superior properties, if DME were to become widely available in large volumes at a reasonable price, DME could be used as a fuel in a wide variety of fields.

2. Development objectives and technology to be developed

The objective of this study is the development of a process to directly synthesize DME from syngas (mixture of H₂ and CO), (Chemical reaction (1)).

Existing technology produces DME through the dehydration of methanol, (Chemical reaction (3)). The scale of the plant in actual operation, however, is rather small, and scaling-up is an issue to produce DME as a commercial fuel. In addition, the equilibrium conversion of the methanol synthesis reaction (Chemical reaction (2)) is relatively small, as show in Figure 1. On the other hand, because the methanol synthesis equilibrium limitation can be avoided in the direct DME synthesis reaction (1), a higher conversion rate can be achieved.

The reaction formulae relating to the direct synthesis of DME are provided below. The equilibrium conversions for methanol synthesis and direct DME synthesis are given in Figure 1. Since direct synthesis produces the maximum conversion with a syngas composition of H₂/CO=1, the process is suitable for the syngas produced from coal gasification (H₂/CO=0.5-1). The targets of the development study include the following:

1. DME production rate: 100 tons/day or greater, syngas total conversion: 95% or greater, DME selectivity: 90% or greater, DME purity: 99% or greater
2. Establishing scale-up technology
3. Optimizing entire system
4. Establishing stable plant operation

Chemical reaction:

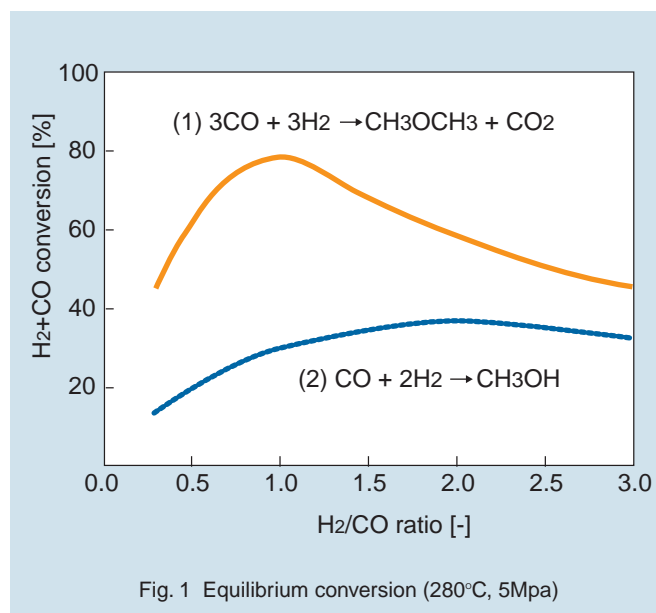
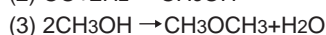
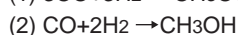
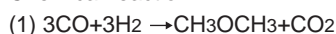


Fig. 1 Equilibrium conversion (280°C, 5Mpa)

3. Progress and development results

The development of the direct synthesis process has been led by JFE. The first step was the search for a direct synthesis catalyst. The second step was a small bench plant (5 kg/day). The third step was a 5 ton/day pilot plant (Photo 1) constructed with the aid of the Ministry of Economy, Trade and Industry (METI). The fourth step was a 100 ton/day demonstration plant (Photo 2) also



Photo 1 Five ton/day pilot plant

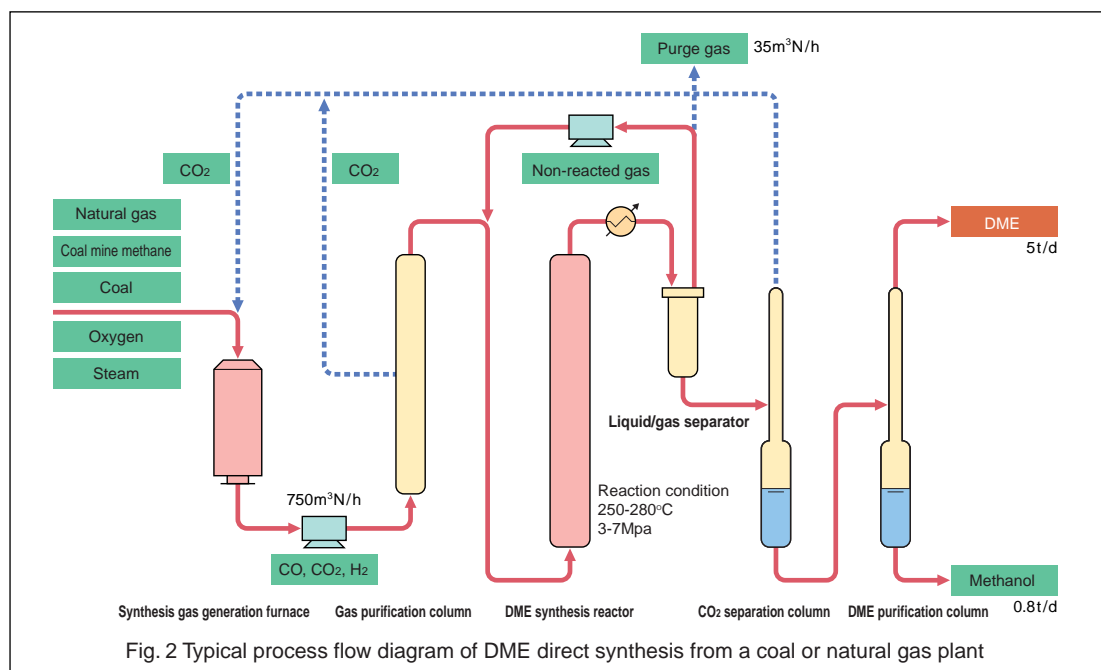


Photo 2 One-hundred ton/day demonstration plant

4. Issues and feasibility of practical application

DME is already utilized as a fuel on a small-scale in an inland area of China. In Japan, activities toward the practical application of DME as a fuel are being undertaken by: DME International Co., Ltd., which was established by the same ten companies that established the DME Development Co., Ltd., aiming to study the commercialization of DME; Japan DME Co., Ltd., which was established by Mitsubishi Gas Chemical Co., Inc., Mitsubishi Heavy Industries, Ltd., JGC, and Itochu Corp.; and Mitsui & Co., Ltd. and Toyo Engineering Corp., which adopted the methanol dehydration process. These activities aim to supply DME product in 2006. All of them plan to use natural gas as the feedstock, because natural gas requires only a small initial investment. In

the future, however, they are expected to switch to coal, which has larger reserves than natural gas, as the feedstock. Using natural gas, the CO₂ obtained from the CO₂ separation column is returned to the syngas generation furnace; if coal were to be used, however, the CO₂ would be released into the atmosphere. When long-term CO₂ storage technology is established in the future, the coal-based process will be able to provide purified CO₂ without any additional equipment. In the West, DME has drawn attention in a wide range of fields as a new fuel. There, however, it is expected to be mainly used in diesel vehicles to fully leverage the fact that DME combustion generates no soot.



References

- 1) Tsunao Kamijo et al., Lecture papers of The 8th Coal Utilization Technology Congress, Tokyo, pp.194-205, 1998.
- 2) Yotaro Ohno et al., Preprint for the lectures of the 30th Petroleum and Petrochemical Discussion Meeting, Tokyo, pp. 26-29, 2000.
- 3) Yotaro Ohno: Japan DME Forum Workshop, Tokyo, pp.113-122, 2002.