CHEMSYSTEMS
PERP PROGRAM

Methanol

Process Technology, (including UOP Methanol from Methane, CHOREN Biomass Gasification, Steam Methane Reforming Synthesis Routes, Coal-based Methanol, Johnson Matthey and Davy Process Technology Compact Methanol MCR process), Production Costs (COP), Regional Supply/Demand Forecasts.

PERP07/08-2

Report Abstract

December 2008

Nexant

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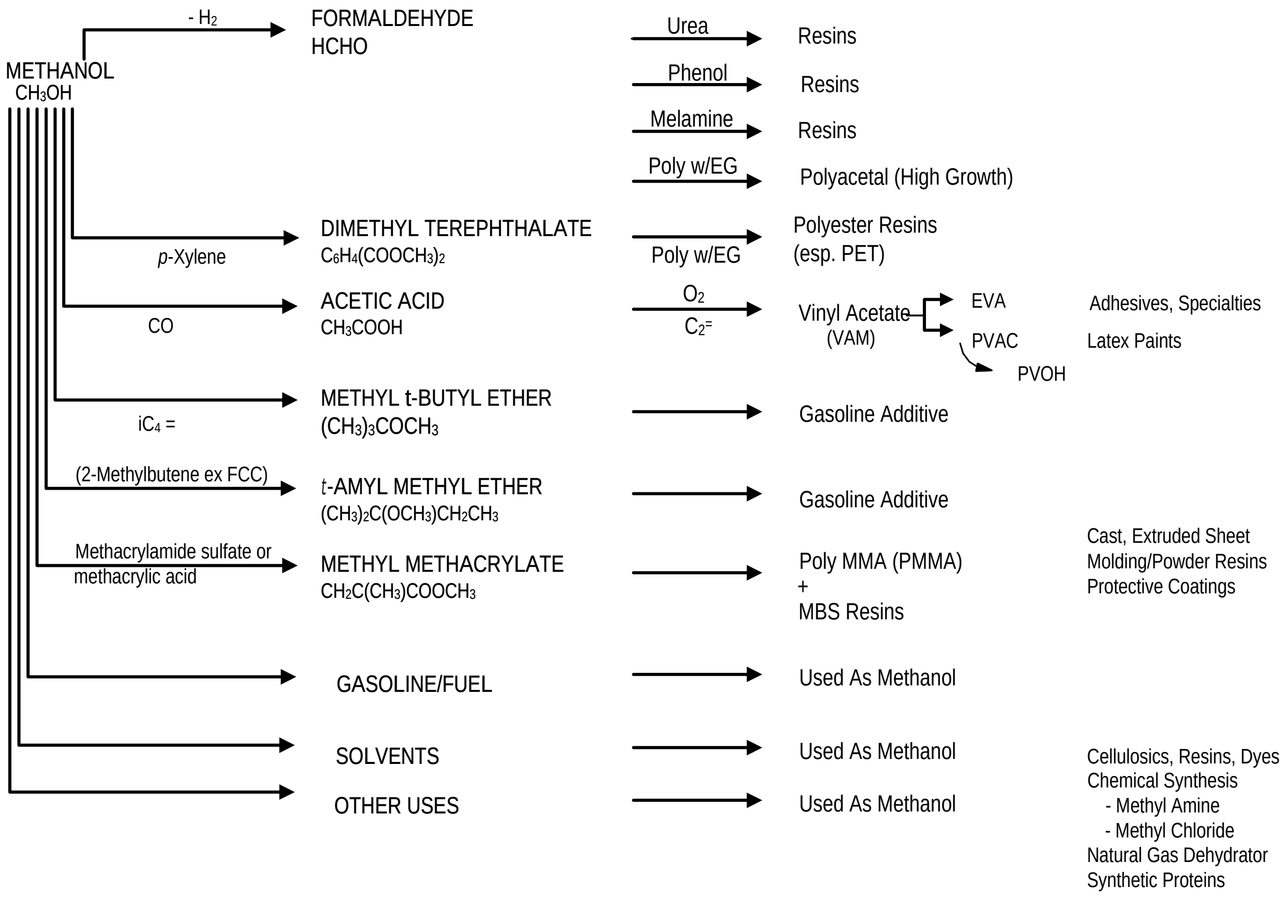
INTRODUCTION

Methanol is a colorless liquid also known as MeOH, wood alcohol, and carbinol. Its volatile, poisonous and flammable nature necessitates special care in handling, transportation and storage.

The use of methanol can be divided into chemical related and fuel related applications. The figure below illustrates the uses and applications that constitute the drivers of methanol demand. Although, there are a large number of applications, the majority of the 2007 global consumption went into the production of formaldehyde, acetic acid, and MTBE. A large proportion of MTBE demand has been reduced because of concerns about groundwater contamination in the United States.



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Methanol-to-Olefins (MTO) and methanol-to-propylene (MTP) are both novel technologies unproven at commercial scale. However, several projects are currently underway in China and planned in Nigeria and Trinidad. Section 6 of this ChemSystems PERP report discusses commercial applications for methanol and includes a detailed market analysis section.

CHEMISTRY

Commercially-viable catalysts that can selectively activate methane to methanol, with an acceptable methane conversion and a reasonably high methanol selectivity, have yet to be established.

Today's practical methanol production technology still employs the less efficient two-step process by first generating synthesis gas (carbon monoxide and hydrogen) from natural gas (methane) or other hydrocarbon feedstocks, such as coal, naphtha, heavy oils and petroleum coke. The synthesis gas generated in the first step is then converted to methanol in the second step.

Certain process chemistry considerations need to be compromised with process engineering considerations. For example, while it is desirable to employ high synthesis pressure in order to achieve high carbon efficiency, the requirements for increased compression duty and increased wall thickness of the equipment and piping due to the increased pressure need to be taken into account. Equally, while low conversion rate per pass will favor high carbon efficiency, it will result in an increased recycle rate and, thus, in a higher compression duty and investment.

The overall reactions to synthesize methanol from natural gas can be expressed as follows:

$$CH_4 + \tfrac{1}{2}O_2 \longrightarrow CO + 2H_2 \longrightarrow CH_3OH \qquad (8)$$

$$CH_4 + H_2O \longrightarrow CO + 3H_2 \longrightarrow CH_3OH + H_2 \qquad (9)$$

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Synthesis gas generation technologies are basically grouped as Partial Oxidation (non-catalytic or catalytic) or Reforming (steam or combined). Process chemistry for methanol production is expanded in section 2.

PROCESS TECHNOLOGIES

As mentioned above, existing commercial technologies for producing methanol are based on a two step process. The different feedstocks that can be used to generate synthesis gas in the first step – either from Natural Gas or Coal/Petroleum Coke – can be used to classify the different process technologies commercially available.

Gas-Based Processes

The methanol production process based on natural gas can be thought of in terms of the following major steps:

- Reforming of hydrocarbon feedstocks for the production of synthesis gas
- Synthesis of methanol from synthesis gas in a converter
- Purification of crude methanol to IMPCA or AA grade methanol by distillation.

All processes contain a gas purification section to remove impurities, primarily sulfur, which could poison the catalysts and a distillation section –two or three stage – to remove impurities from the crude methanol produced in the synthesis section.

There are several variants of methanol technology available or under development. Section 2.3 reviews some of the main process options.

Coal/Petroleum Coke Gasification-Based Processes

Essentially, all of the important first-stage organic petrochemicals were made from coal during the period of about 1900-1930. However, inexpensive oil and natural gas liquids motivated the chemical industry to switch almost completely to natural gas and petroleum liquids over the 1940-1965 period. Today, coal gasification has been concentrated in regions that experience shortages of natural gas as well as high natural gas costs.

There are three major types of gasifiers: moving or fixed-bed, entrained-flow, and fluidized-bed. In summary terms, the gasifiers can be described as follows:

- In moving-bed (also called fixed-bed) reactors, large particles of coal move slowly down through the gasifier while reacting with gases moving up through it. Several different "reaction zones" are created that accomplish the gasification process
- Fluidized-bed reactors efficiently mix feed coal particles with coal particles already undergoing gasification in the reactor vessel. Coal is supplied through the side of the reactor, and oxidant and steam are supplied near the bottom. Few of these systems are currently in operation
- Entrained-flow systems react fine coal particles with steam and oxygen and operate at high temperatures. These systems have the ability to gasify all coals regardless of rank. Different systems may use different coal feed systems (dry or water slurry) and heat recovery systems. Nearly all commercial IGCC systems in operation or under construction are based on entrained-flow gasifiers

Section 2.4 discusses coal/petroleum coke gasification based processes, including the licensed technologies offered by Chevron Texaco/GE, Lurgi, and Shell.

Technology Developments

Important developments are constantly being made with respect to process and equipment design and catalyst for all of the numerous steps used in methanol production.

An overview of the type of research being performed to improve the methanol production process is given in this section. In particular, section 3.2 gives a patent review which outlines some developments by INEOS, Methanol Casale, Davy Process Technology and Haldor Topsoe.

Carbon dioxide reforming for producing syngas has increasingly attracted significant attention by both industrial and academic researchers. The key to feasible CO_2 reforming, both technologically and economically, is catalysts that are suitable at high CO_2 concentration and in the absence of steam. Developments in this area are briefly discussed in section 3.3.

One of the recent major process technology developments has been the introduction by UOP of a process for the direct production of methanol from methane. UOP stated that the new technology could significantly lower the cost of production of methanol. This is discussed further in section 3.4.

Biomethanol production substitutes the hydrocarbon feedstocks used to generate syngas with various forms of biomass, such as rice straw, husks of rice, sorghum, wood chips, sawdust, MSW, etc. The biomass feed is first dried and crushed before it is fed to a gasifier where gasification or partial oxidation takes place to produce raw syngas. Biomass gasification technology by CHOREN is described, and work by other companies is outlined in section 3.5. In addition, this section gives a brief outline of the polygeneration process: the gasification of coal producing syngas that can be used partly for the generation of electricity in conventional integrated gas/team turbine combined cycle (IGCC) systems, and partly for the concurrent production of liquid fuels or commodity chemicals such as methanol.

Section 3.6 describes the Liquid Phase Methanol Process technology project by Air Products and Eastman Chemical Company.

Current Commercial Methanol Technologies

Methanol technology is licensed by a number of companies. Johnson Matthey and Davy Process Technology benefit from a suite of syngas and methanol technologies resulting from the combined technologies following the formation of an exclusive partnership in 2004. The acquisition of Davy Process Technology by Johnson Matthey in 2006 made this partnership even stronger. Methanol technologies, licensed by this partnership, are branded as Davy Process Technology (DPT) and Johnson Matthey Catalysts (JM).

Section 4.3 gives detailed descriptions of process technologies offered by DPT/JM: Low Pressure Methanol (LPM), Leading Concept Methanol (LCM), Improved Low Pressure Methanol (ILPM), and Combined Reforming.

According to DPT & JM, Compact Methanol (MCR) process technology is being developed to meet the need to build plants in remote or offshore locations where specialist construction resources would be prohibitively costly. This new methanol process, outlined in section 4.3.5, features:

- Pre-reformer - using a catalytic rich gas (CRG) technology
- Compact Reformer - integrates preheating, steam reforming and waste process heat recovery in a single process compact unit. These proprietary units are factory built and shipped ready for installation thereby reducing on-site specialist resources, project costs and construction schedule
- Davy Process Technology Steam Raising Converter

If a project has gas and offshore operation as an option, then the first consideration is the type of structure to put the plant on. Section 4.3.6 discusses the two basic types that DPT & JM believe are appropriate:

- Fixed system such as a CGS (Concrete Gravity Structure)
- MFPSO (Methanol Floating Production, storage and offloading)

In addition to DPT/JM, detailed descriptions of methanol production process technologies offered by the licensors listed below, are given in sections 4.4-4.9.

- UHDE,
- LURGI,
- Mitsubishi Gas Chemical,
- Haldor Topsoe and
- Methanol Casale

A Steam Methane Reformer (SMR) based process for large plant capacities offered by Jacobs using methanol synthesis and distillation licensed technology from JM is also described in this section.

ECONOMIC ANALYSIS

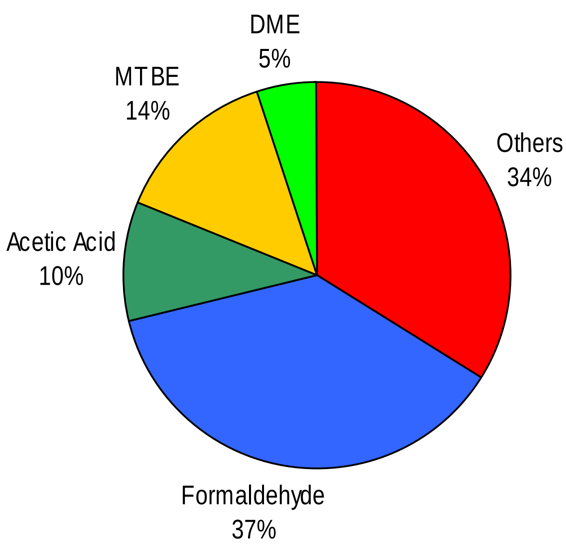
Production cost estimates based on natural gas and coal (and subsequently different capacities) have been analyzed and compared in section 5. Details are included on investment requirements, variable and fixed costs, and capital charges. The selected cases are:

- Methanol Process employing Steam Methane Reforming (United States Gulf Coast)
- Methanol Process employing Steam Methane Reforming (Central America)
- Methanol Process employing Steam Methane Reforming (Middle East)
- Methanol Process employing Coal (China)

MARKET ANALYSIS

Section 6 of this report includes a market review for the United States, Western Europe, and Asia Pacific regions. The forecast timeframe is to 2011.

Asia Pacific Methanol Demand by End-Use, 2007



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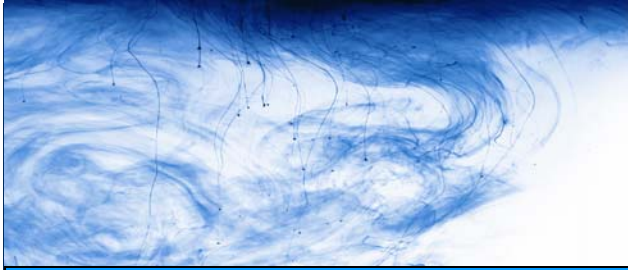
As can be noted from the figure, Asia Pacific demand is dominated by its use in formaldehyde applications. Expected average growth rate in the forecast period, along with the drivers for this are also given in this section. Pertinent country specific data within the region is included. For example, Chinese demand for 2007 and estimated methanol consumption growth rates until 2011 driven by specified emerging uses is detailed.

Similarly, United States, Western Europe, and Asia Pacific supply, demand and trade data are given, along with tables detailing specific company, location and plant capacities for each region. Notably, a comprehensive listing of Chinese capacity is included.



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