Abstract
Process Economics Program Report No. 208
ETHYLENE FROM METHANE
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This report evaluates two routes for the production of ethylene from methane: the direct synthesis based on the oxidative coupling of methane, and the less direct chemistry of converting methanol (which is derived from methane via synthesis gas) in the presence of an aluminophosphate molecular sieve catalyst. Our evaluations indicate that at the present state of development, the economics of both routes are unattractive when compared with the steam pyrolysis of hydrocarbons. We analyze the results of our evaluations to define the technical targets that must be attained for success.

We also present a comprehensive technical review that examines not only the two routes evaluated, but also some of the more promising alternative approaches, such as synthesis gas conversion via a modified Fischer-Tropsch process, ethanol synthesis by the homologation of methanol, and ethylene production via methyl chloride.

This report will be of interest to petrochemical companies that produce or consume ethylene and to energy-based companies (or equivalent government organizations in various countries) that have access to or control large resources of methane-rich natural gas.
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1 INTRODUCTION

The economic conversion of methane to ethylene and other similar higher value products is still a much desired research objective. Interest in processes for upgrading methane has been stimulated mainly by recent growth in natural gas reserves (particularly between 1980 and 1990), which has far outpaced that for crude oil. To some extent, the interest in methane-based routes to ethylene is also driven by possible future shortage of light paraffin feedstocks such as ethane, propane, and butanes, which cost less for producing ethylene than do heavier liquid feedstocks. The lighter paraffin feedstocks are neither as widely accessible nor as likely to be available in sufficient quantities to support the future growth in ethylene demand.

We previously examined the production of ethylene from methane in PEP Report 191, *Utilization of Remote Methane*, July 1989, and Report 146, *Bulk Chemicals from Synthesis Gas*, June 1982. The more recent report evaluates two routes to ethylene, one based on the oxidative coupling of methane and the other route via the zeolite catalyzed conversion of syngas-derived methanol. PEP Report 146 examines the more direct ethylene synthesis from a CO-H₂ (syngas) mixture, using a modified Fischer-Tropsch catalyst system along with an earlier version of a methanol-based process. In PEP Reviews we have evaluated various other routes to ethylene from methane, most notably in Reviews 82-2-1, *Ethylene from the Methane-chlorine Reaction System*, September 1982, and 80-1-3, *Ethylene from Methanol Homologation*, March 1981.

In this report, we reevaluate the production of ethylene from methanol and from the oxidative coupling of methane. In contrast to many alternative approaches, these two routes have evidenced significant technological advances. We also appraise the current status of the more promising alternatives in a technical review section of the report. These alternatives include the modified Fischer-Tropsch synthesis, methanol homologation, and the conversion via methyl chloride.

We analyze and discuss the results of our evaluations to identify the principal technical challenges that process developers currently face and define the research targets that they must accomplish to furnish a viable process. To quantify these targets, we use the production costs of ethylene by the steam pyrolysis of ethane as the reference yardstick.