



Ethylene Oxide/Ethylene Glycol

Process Economics & Production Technologies compared. Dow METEOR™, Scientific Design and Shell's OMEGA processes reviewed. Capacity, Supply/Demand forecasts given.

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CHEMSYSTEMS PERP PROGRAM

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INTRODUCTION

Ethylene oxide (also know as epoxyethane and oxirane) is a colorless gas at temperatures above 10.7 $^{\circ}$ C (51.3 $^{\circ}$ F) with a sweet smell.

Ethylene oxide is a chemical intermediate key to the manufacture of many important products used in a wide range of downstream markets. When initially produced it is referred to as crude ethylene oxide and contains aldehydes and other impurities. Most derivatives of ethylene oxide, other than ethylene glycol and the corresponding higher glycols formed in the production of ethylene glycol, require a more purified version of ethylene oxide for use as a raw material. Purified ethylene oxide is not produced by all producers of crude ethylene oxide, particularly those who convert all their ethylene oxide production to glycol.

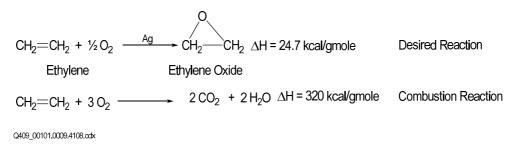
Currently, about 74 percent of the world's ethylene oxide demand is consumed in the production of ethylene glycol. Ethylene glycol (MEG) is a colorless liquid, utilized in the production of antifreeze, polyester fiber, PET bottle resins, polyester film, and a variety of other applications, including aircraft and runway deicing fluids. Historically, about 20 percent of the ethylene glycol was consumed in antifreeze applications. However, the demand for antifreeze has been overshadowed by the demand for PET. Some antifreeze applications have been converted to the use of propylene glycol based coolants. In addition, longer drain time intervals for antifreeze have led to a slowdown in the growth rate.

This report details process chemistry, technology and economics for ethylene oxide and ethylene glycol. A commercial analysis section detailing market applications, regional supply/demand and trade is included, as well as an outline of storage, handling and transportation requirements.

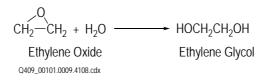


CURRENT COMMERCIAL EO/MEG TECHNOLOGIES

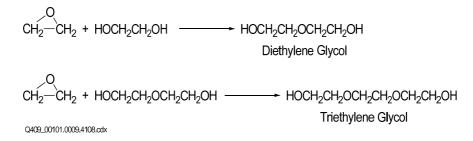
Ethylene oxide is produced commercially by the vapor phase oxidation of ethylene over a silverbased catalyst. Selectivity to ethylene oxide equivalents depends on the catalyst employed. New catalyst development is aimed at developing selective silver-based catalysts to minimize combustion of ethylene to carbon dioxide, carbon monoxide, and water. The overall chemistry of the desired reaction and competing degradation reaction is as follows:



Ethylene glycol is commercially produced by the liquid phase non-catalytic hydrolysis of ethylene oxide, as an integrated product of an ethylene oxide plant. The process is carried out with greater than 20 times molar excess of water in order to minimize higher glycol by-products. The overall chemistry is as follows:



Higher glycols form by the interaction of ethylene oxide with ethylene glycol; the oxide is more reactive with glycol than with water. The reactions for diethylene glycol and triethylene glycol are shown below.



This section of the report reviews the technical features of commercially available processes offered by the major licensors of ethylene oxide and ethylene glycol technology. These companies represent the main suppliers of ethylene oxide and ethylene glycol technology and cover the full spectrum of process variations.

■ Dow offers its METEORTM (Most Effective Technology for Ethylene Oxide Reactions) EO/MEG process for the production of ethylene oxide and ethylene glycol. A review of this process technology including pertinent flow diagrams is given in the report

- Scientific Design Company (acquired jointly by Saudi Basic Industries Corporation (SABIC) and Süd-Chemie in 2003) developed its ethylene oxide/ethylene glycol process and started manufacture of EO catalysts in the 1950s. Scientific Design is a major licensor of EO/EG technology and the report reviews the technology offered by this company including pertinent flow diagrams.
- Shell Global Solutions' two processes for the production of ethylene oxide and ethylene glycol - the Shell MASTER and the Shell OMEGA process – are reviewed in the report including relevant process flow diagrams.

TECHNOLOGY TRENDS

Recent technology trends in ethylene oxide and ethylene glycol processes involve research and development in the process and equipment design and catalysts utilized in their production. The report includes a summary of these and is intended to give a brief overview of the type of research being performed to improve the ethylene oxide and ethylene glycol production processes.

ECONOMIC ANALYSIS

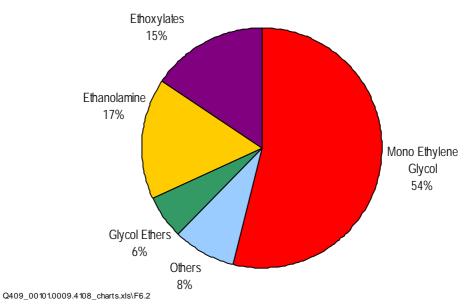
Several cases have been considered for the production of ethylene oxide and ethylene glycol. These cases, with the exception of the Shell OMEGA process, do not necessarily represent any one specific technology owner, but rather, represent "state-of-the-art processes". The selected cases are:

- Ethylene Oxide via ethylene oxidation
- Ethylene Glycol via ethylene oxidation/ethylene oxide hydration with DEG/TEG by-products valued at market prices
- Ethylene Glycol via OMEGA process
- Ethylene Glycol/DEG/TEG product slate via ethylene oxidation/ethylene oxide hydration.

COMMERCIAL ANALYSIS

This section provides a regional market review for ethylene oxide and ethylene glycol for the United States, Western Europe, and Asia Pacific regions. The forecast timeframe is to 2014.

U.S. ethylene oxide demand by end-use is shown in the Figure below. The demand is largely determined by the demand for ethylene glycol. However, this situation will change as MEG exports from the United States will continue to decrease further in the forecasted period.



U.S. Ethylene Oxide Consumption by End-Use

For both Ethylene Oxide and Ethylene Glycol:

- Supply/demand and trade data are presented and discussed for the U.S., Western Europe and Asia Pacific regions.
- Capacity tables listing company, location and specific site production output for all three regions are given.



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