Ethylene Glycol process alternatives

Ethylene glycol is a clear, odorless, viscous liquid with a sweet taste that can produce dramatic toxicity. In an industrial setting, it's used as a solvent or as the raw material for a variety of processes. It's found most commonly as antifreeze for automotive cooling systems and hydraulic brake fluid. The excellent humectant (hygroscopic) properties of ethylene glycol products also make them ideal for treating textile fibers, tobacco, paper adhesives, printing ink, leather and cellophane. It's used in the manufacture of polyester films and fibers, polyethylene terephthalate (PET) solid state resins, plasticizers and elastomers. It's commercially available in three grades: fiber grade, industrial grade and antifreeze grade.

Ethylene glycol is widely used as an industrial organic intermediate. In 1995, it's production volume ranked it among one of the top twenty organic chemicals in the United States. Nearly all ethylene glycol (EG) is made from ethylene oxide (EO) by thermal hydration.

Process description:
An aqueous solution of (EO) is fed to a reactor, in the reactor EO is hydrated to produce monoethylene glycol MEG, and small amounts of diethylene glycol DEG and triethylene glycol TEG.

After the product passes through the reactor, it enters an evaporation system. Here water is evaporated from the glycol-water mixture. The evaporated water is recycled back to the EO plant (existing EO plants are integrated with EG production, with part or all EO processed into EG in situ).

The concentrated crude glycol solution is fed to a stripper where the remaining water and light impurities are removed. The water-free solution is then distilled in a series of vacuum towers to separate MEG, DEG and TEG from glycol.

It should be emphasized here that heat exchangers selection is of great importance, since heat exchangers (HE) can reduce the capital equipment costs and increase efficiencies, for example the reactor feed recycle interchanger HE should be gasket plate type where for the reboiler of the evaporator system, the HE should be plate type, some other important units would be a condenser for the light ends column, a reboiler for the purification columns, a product cooler gasket plate HE, and a spiral type HE for the water recycle condenser and glycol condenser.

Other routes to EG have been proposed, these include routes via ethylene carbonate, and from ethylene by direct hydroxylation with water and oxygen. Proposed routes from ethylene include those via glycol esters and via 1,2-dichloroethane, other routes use peroxides along with an old one via ethylene chlorohydrin.
Other inexpensive raw materials have also been considered for making EG like the syngas (mixtures of CO and hydrogen). Other two-step process for making EG is from formaldehyde by hydroformylation to glycoaldehyde, also from methanol and one from CO via oxalate esters, and some of these routes are to be discussed now.

Process alternative description:

One process alternative has been evaluated for making ethylene glycol from CO, hydrogen and oxygen by the formation of dimethyl oxalate as an intermediate followed by hydrogenation of the oxalate to glycol. Dimethyl oxalate is made by a vapor phase operation in which methyl nitrite reacts with CO. The oxalate route is indicated to require a slightly lower investment and to produce glycol at a somewhat lower production cost and product value than the ethylene route, however the economic prospects for the oxalate route to glycol are unattractive.

The technology for producing ethylene glycol directly from syngas (mixture of hydrogen and carbon monoxide) has focused on a high-pressure liquid phase process that uses a homogeneous catalyst and a high-dielectric solvent.

The catalyst complex is based on rhodium or ruthenium, generally with a ligand and a nitrogen-containing lewis base, development work on the catalyst has been aimed at producing a stable system that gives high selectivity to EG and can be removed with very low losses of precious metal. Selectivity to EG seldom exceeds 75% and the reactor product is dilute. Reactor pressure must be at least 8000 psig, with residence times of at least 1.5 hr.
Before the syngas process can be commercialized, it will be necessary to improve EG selectivity, lower the operating pressure, increase product concentration, or reduce residence time.

Literature indicates that several companies have developed glycol processes based on the direct catalytic oxidation of the olefins in the presence of acetic acid to glycol acetates. The acetates are then hydrolyzed to glycols thus avoiding the intermediate production of the olefin oxides. Rough design and economic studies have been made on a direct oxidation process for the large scale production of ethylene glycol and the economics compared with the two step synthesis through ethylene oxide. It’s concluded that direct oxidation looks quite promising, permitting savings in both investment and production cost.

Published information on the technologies for manufacturing ethylene glycol by ethylene oxidation to glycol esters followed by ester hydrolysis has been developed into process design and economics.

The yield, investments and production costs for this method appears to be essentially equivalent; therefore the choice may depends on such factors as catalyst replacement costs. However it gives better yield on ethylene, lower glycol costs and some savings in capital investment as compared with the conventional route via ethylene oxide.

From the previous information about process alternatives for the EG, it can be concluded that EG has a selectivity that seldom exceeds 75% and usually it’s production process requires high pressure operation in the reactor for some processes, on the other hand some of these routes appeared to be promising while other routes appeared to be commercially
unattractive, however there are some important factors to be considered including the catalyst price, residence time and the price of the raw material.