Propylene Oxide

Marianne Asaro, Senior Principal Analyst

Abstract
This report consolidates and updates the Process Economics Program’s technical and economic analyses of propylene oxide (PO) manufacturing technologies from 1970 to the present. PO is consumed primarily as a comonomer in the production of polyether polyols, most of which are used to manufacture polyurethanes. Polyurethanes derived from PO are applied to the manufacture of rigid and flexible foams, elastomers, adhesives, sealants, coatings, and fibers. Lower-volume, nonurethane applications of PO include polyether polyl surfactants and demulsifiers; propylene glycol for de-icing, fiberglass, and hydraulic fluids; propylene oxide glycol ethers and propylene carbonate solvents; polyalkylene glycol fuel additives and lubricants; and numerous others.

Almost half of current global PO capacity uses processes based on oxidation of propylene by the organic hydroperoxides ethylbenzyl hydroperoxide (EBHP) and tert-butyl hydroperoxide (TBHP), at about 27% and 15%, respectively. The EBHP and TBHP processes coproduce more tonnage of their by-products (styrene and t-butanol, respectively) than PO; however, despite concerns over the years, the markets for their coproducts continue to support the PO processes.

The chlorohydrin route is disfavored for new plant start-ups in most locations, owing to its coproduction of copious saline wastewater, but still accounts for about 41% of global PO capacity. The environmental viability of a modern chlorohydrin plant rests on its scale of production, wherein large-scale plants can be fully integrated with chlorine/caustic plants.

Lower-volume commercial processes include hydroperoxidation using cumyl hydroperoxide as an oxidant, at 2% of global capacity, and the newer HPPO processes using hydrogen peroxide, at 15% of global capacity. New start-ups or expansions at mid- to large-scale have been announced using the HPPO and TBHP processes, with a few small-scale plants announced using chlorohydration.

Technical descriptions and economic analyses are provided herein for the following ten technologies, all of which use propylene as feedstock:

- The LyondellBasell process for PO and t-butyl alcohol by hydroperoxidation using TBHP
- The Huntsman process for PO and t-butyl alcohol by hydroperoxidation using TBHP
- The LyondellBasell process for PO and styrene by hydroperoxidation using EBHP
- The Shell process for PO and styrene by hydroperoxidation using EBHP
- The Sumitomo process for PO by hydroperoxidation using cumyl hydroperoxide (CHP)
- The BASF-Dow process for PO by hydroperoxidation using hydrogen peroxide (HP)
• The Evonik–Uhde process for PO by hydroperoxidation using HP

• The AIST-Nippon Shokubai, non-commercial process for PO by reaction of propylene, O₂, and H₂ in the same reactor

• The chlorohydrin process for PO by chlorination followed by treatment with calcium hydroxide derived from lime

• The chlorohydrin process for PO by chlorination followed by treatment with sodium hydroxide

These and other technologies past, present, and emerging for PO production are reviewed with a bibliography and abstracts for relevant patents since the 1950s. The industry status is updated, the modern PO processes are summarized in terms of comparative economics and the key process indicators (KPI) of capital intensity, energy intensity, carbon efficiency, and carbon intensity. Lastly, the iPEP Navigator PO tool is attached to the electronic version of this report. The iPEP Navigator interactive module provides an economic snapshot for each process, allowing the user to select and compare the processes, units, and regions of interest.
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