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CR002

On Purpose Linear Alpha Olefin Processes

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Abstract

This report consolidates and updates the Process Economics Program's technical and economic analyses of on-purpose linear alpha olefin (LAO) manufacturing technologies published through 2013. LAO are used as comonomers in polyethylene production and in the plasticizer, detergent, and lubricant markets. Almost half of the LAO produced worldwide today come from large-scale processes that make a wide range of LAO, with carbon numbers in the range C_4-C_{20+}. Recent entrants into the market include on-purpose processes, focused predominantly on one LAO product: 1-butene, 1-hexene, or 1-octene. Major producers of on-purpose C_6 or C_8 LAO from ethylene include Chevron Phillips, Sasol, and Saudi Polymers. Smaller-scale producers of on-purpose 1-hexene include Q-Chem, Mitsui, and Yanshan PC. Numerous companies have licensed the selective ethylene dimerization technology of IFP for production of 1-butene, typically operating at very small scale.

The majority of 1-butene is produced by on-purpose isolation from mixed C_4 streams, particularly steam cracker raffinate. The C_4 components of raffinate boil too closely to separate economically by simple distillation. The dominant raffinate-based process involves upfront removal of butadiene by reactive distillation, followed by conversion of isobutylene to MTBE, and then distillative separation of the 1-butene. The MTBE may be sold or cracked in-house to give isobutylene of very high purity (HPIB). 1-Butene also can be isolated from raffinate by selective adsorption, as developed by UOP and by Union Carbide. Selective adsorption processes do not appear to be in current use, likely because the HPIB produced via MTBE is of relatively high current market value. Alternatively, raffinate streams may be significantly enriched in 1-butene prior to downstream isolation of the C_4 LAO by selectively hydrogenating the butadiene contact of crude raffinate.

On-purpose LAO are also produced from Fischer-Tropsch effluents, as practiced commercially by Sasol. Dow Iberica selectively produces 1-octene in a small-scale process using 1-butene as feed. Additional on-purpose LAO processes are commercialization-ready or under development, including metathesis of 1-butene from raffinate to give hexene and ethylene as commercialized at demonstration scale by Lummus/CB&I.

Technical descriptions and economic analysis are provided herein for the following technologies:

- 1-Octene and 1-hexene by the Sasol ethylene tetramerization process
- 1-Hexene by the Chevron Phillips ethylene trimerization process
- 1-Hexene by the Axens ethylene trimerization process
- 1-Hexene by the Lummus C_4 metathesis process
- 1-Butene by the Axens-IFP-SABIC ethylene dimerization process
- 1-Butene by distillation of raffinate-2 from MTBE production
- 1-Butene from raffinate-1 by the UOP adsorption process
- 1-Butene and isobutylene from raffinate-1 by the UCC adsorption process
- 1-Butene-enriched C_4 by selective hydrogenation of butadiene

These and other technologies past, present, and emerging for on-purpose LAO are reviewed, with bibliography and abstracts for relevant patents since the 1980s. The industry status is updated, and a summary is provided of all commercial or commercial-ready intermediate- to large-scale on-purpose LAO processes in terms of comparative economics and the key process indicators (KPI) of carbon efficiency, energy intensity, carbon intensity, and capital intensity. Lastly an interactive module is included, the iPEP Navigator OPLAO tool, which provides a snapshot of economics for each process and allows the user to select the process, units, and region of interest.

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