



Developments in Linear Alpha Olefin (LAO) Comonomer Technologies for Polyethylene

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INTRODUCTION

The technology for alpha olefins production (higher than ethylene and propylene) is divided into two categories:

- Full-Range Alpha Olefins
- On-Purpose (or Single Fraction) Alpha Olefins

Full-range processes produce a wide distribution of products. Although the distribution can be controlled to a certain degree, the various products supply a range of very different markets, making it difficult to match supply and demand. Although much of the production comes from full-range ethylene oligomerization, on-purpose production for the polyethylene comonomers market is increasing. The low carbon number components (butene-1, hexene-1, and octene-1) are mainly consumed as comonomers for the production of polyethylene, which represents the largest volume market for alpha olefins. Thus, producers who do not want to rely on sourcing from full-range plants are increasingly looking at on-purpose production of the desired alpha olefin. In addition, the polyethylene industry remains the major growth driver for alpha olefin comonomers, with growth rates (and volumes) in excess of other industries served by alpha olefins production.

The supply of linear alpha olefins has been dominated by three major producers, Chevron Phillips, INEOS, and Shell, who operate a number of full-range plants. However, for the polyethylene comonomer fractions, this has been changing. On-purpose plants making butene-1 (extraction and dimerization), dominate the supply of this comonomer. Although not as extensive, on-purpose production of hexene-1 and octene-1 is also increasing.

The focus of this report is on the technologies that produce the alpha olefins used as comonomers for polyethylene production – butene-1, hexene-1, and octene-1. Although the full-range processes are discussed, most are well-established and the discussions will focus on their production of the alpha olefins of interest.

FULL-RANGE TECHNOLOGY

Full-range technologies cover those processes based on ethylene oligomerization that produce alpha olefins from C_4 (butene-1) through C_{30} + (triacontene-1). Different technologies in commercial operation vary in their design and provide a maximum limit on carbon number. Newer technologies, some of which have been commercialized, have tried to focus on particular carbon number ranges. The major, well-established commercial full-range technologies discussed in this report are:

- Chevron Phillips
- INEOS
- Shell SHOP

The above technologies are generally not available for license, but are used internally and in joint ventures. The newer full-range technologies that have been developed are available for license. The technologies discussed in this report are:

- Axens AlphaSelectTM (not commercial)
- SABIC/Linde ALPHA-SABLIN[®] (commercial)
- UOP LINEAR-1[®] (not commercial)

ON-PURPOSE TECHNOLOGY

Commercial on-purpose (or single-fraction) alpha olefin technology was once only used for the production of butene-1 from petrochemical/refinery C_4 streams. Ethylene dimerization is now commercial with a number of licensed units worldwide. On-purpose hexene-1 production and on-purpose octene-1 production have also been commercialized.

The on-purpose alpha olefin technologies for butene-1 production covered are:

- Axens AlphaButol[®] (ethylene dimerization, commercial)
- Zeon Corporation (extractive distillation, commercial)

The on-purpose alpha olefin technologies for hexene-1 production covered are:

- Axens AlphaHexolTM (ethylene trimerization, licensed, but not commercial)
- Chevron Phillips (ethylene trimerization, commercial)
- Lummus (C₄ auto-metathesis, licensed, but not commercial)
- Sasol (extraction from Fischer-Tropsch, commercial)

The on-purpose alpha olefin technologies for octene-1 production covered are:

- Dow (butadiene telomerization, commercial)
- Sasol (extraction from Fischer-Tropsch, commercial)
- Sasol (via heptene-1, commercial)
- Sasol (ethylene tetramerization, under construction)

PROCESS ECONOMICS

Cost estimates for alpha olefins production via the following full-range technologies were evaluated:

- Chevron Phillips for plant capacity 350 kta on a USGC and Middle East basis
- INEOS for plant capacity of 350 kta on a USGC and Middle East basis
- Shell for plant capacity of 350 kta on a USGC and Middle East basis
- SABIC/Linde for plant capacity of 150 kta on a USGC, Middle East, and China basis
- Axens' AlphaSelect (non-commercial) for plant capacity of 100 kta on a USGC, Middle East, and China basis

Cost estimates for on-purpose butene-1 production via the following technologies were evaluated:

- Axens' AlphaButol for plant capacity of 30 kta on a USGC and China basis and for plant capacity of 50 kta on a Middle East basis
- Extractive distillation for plant capacity of 100 kta on a USGC basis and for plant capacity of 50 kta on a China basis

Cost estimates for on-purpose hexene-1 production via the following technologies were evaluated:

- Chevron Phillips for plant capacity of 100 kta on a USGC and Middle East basis
- Axens' Alpha Hexol (non-commercial) for plant capacity of 40 kta on a USGC, Middle East, and China basis
- Lummus (non-commercial) for plant capacity of 50 kta on a USGC and China basis
- Sasol for plant capacity of 220 kta on a South Africa basis, delivered to the markets analyzed

Cost estimates for on-purpose octene-1 production via the following technologies were evaluated:

- Dow for plant capacity of 50 kta on a USGC and China basis
- Sasol (Fischer-Tropsch) for plant capacity of 100 kta on a South Africa basis, delivered to the markets analyzed
- Sasol (heptene-1-based) for plant capacity of 100 kta on a South Africa basis, delivered to the markets analyzed
- Sasol (tetramerization, non-commercial) for plant capacity of 100 kta on a USGC, Middle East, and China basis

Detailed cost tables are presented for the USGC and South Africa locations, while summary tables are included for the other locations. All detailed cost tables given in this report include a breakdown of the cost of production in terms of raw materials, utilities, and direct and allocated fixed costs. These categories are presented by unit consumption, per metric ton, and annually. The contribution of depreciation and a simple nominal return on capital are also included to arrive at a cost estimate.

COMMERCIAL MARKET REVIEW

Demand for butene-1, hexene-1, and octene-1 account for more than 50 percent of global demand for linear alpha olefins, with polyethylene representing the largest end use.





Global Alpha Olefin Demand by End Use

- Commercial applications and end uses for alpha olefins are discussed
- Global demand, supply, and net trade data for butene-1, hexene-1, and octene-1 are provided and discussed
- In addition, demand, supply, and net trade data for butene-1, hexene-1, and octene-1 are provided and discussed by region (North America, Western Europe, Asia Pacific, and Rest of World)
- A list of plants in each of these regions is given showing company, location, current plant capacity, and production method



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