Developing Fortunes of the C4 Value Chain
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Section 1

Introduction

A severe tightness in global butadiene markets has drawn considerable attention to the C₄ value chain and its prospects for future development. Structural changes in global olefin feedstock selection, supply additions and plant production utilization have resulted in both shortages and unpredictability in mixed C₄ supply. In addition, record highs in natural rubber prices have supported higher demand for synthetic rubbers as well as butadiene in 2011. With a tightening mixed C₄ feedstock supply and consistent derivative demand, the price of butadiene has increased dramatically culminating in record highs in 2011. Furthermore, pricing has becoming extremely volatile with large fluctuations in price spreads occurring over relatively short time frames.

The current and evolving landscape remains highly unpredictable due to the complex nature of the C₄ value chain. A key issue facing the industry today is tied to availability and production of mixed C₄s from steam crackers. The global landscape for olefins production is in a state of transition, characterised by changing in feedstock slates in different regions. Co-production of mixed C₄s and available butadiene, is becoming increasingly difficult to forecast, and ultimately contributing to erratic pricing levels.

Nexant has recently completed a new report that provides detailed insights and analysis into the industry dynamics that will shape the C₄ value chain over the next decade. This prospectus outlines Nexant’s approach and details key areas of focus and analysis in the report.

Figure 1.1 illustrates historical butadiene price relative to naphtha price.
1.1 C₄ SUPPLY DRIVERS

1.1.1 Source of C₄ Supply

In general, petrochemical feedstock slates employed differ greatly by region due to availability and cost by location. This is more prevalent in the production of olefins where there are a number of different options available to producers in different geographies. Figure 1.2 displays global ethylene production by feedstock slate. Currently around half of the world’s ethylene capacity utilizes naphtha as its feedstock while ethane, other natural gas liquids and gas oil comprise the balance.

Different steam cracker feedstocks provide contrasting yields of mixed C₄S. Generally, heavier feedstocks, such as naphtha and gas oils provide higher C₄ yields that make extraction and recovery both viable and increasingly attractive in terms of overall olefin production competitiveness.

The recent unprecedented highs in C₄ values have resulted directly from several key supply factors which include the following:

- A trend towards investments in **lighter feedstock cracking**, promoted primary by advantaged feedstock pricing and availability in the Middle East.
- **Impact of shale gas** in North America, leading to a shift towards lighter feedstock slates for olefin production.
- Lower utilisation rates for selected higher cost naphtha steam cracker, resulting from decreased demand for ethylene and ethylene derivatives.
- Other production trends for ethylene and propylene from **non-conventional technologies** such as coal-to-olefins, metathesis, propane dehydrogenation and biomass which do not yield mixed C₄ streams.

**Figure 1.2  Global Ethylene Production by Feedstock Slate**
Capacity to produce ethylene by feedstock type is an important component in determining the potential mixed C_4 availability. However, Nexant’s study also incorporates detailed estimates of individual cracker production levels to determine the actual level of mixed C_4S available. Nexant’s database models each individual cracker in terms of capacity, production and feedstock slate to determine its C_4 balance. The analysis in the study covers a 20-year timeframe to accurately present historic and forecasted trends of supply.

Figure 1.3 depicts global ethylene capacity compared with the production and global mixed C_4 production. Nexant’s analysis further incorporates available C_4 versus production with estimates for butadiene production versus recycle co-cracking.

In the study, Nexant will provide detailed analysis of current C_4 supply and forecasted trends on a regional basis. Nexant’s C_4 availability is derived by a detailed analysis of individual steam cracker sites around the world. Key inputs include: capacity, production rate, C_4 recovery and feedstock employed. This will provide a number of useful insights such as the impact of light gas cracker investments in the Middle East and the impact of shale gas on the sector in North America.

1.1.2 Complexity of C_4 Products Configuration

Figure 1.4 illustrates the many schemes for upgrading the C_4 stream. The C_4 flow scheme illustrates a wide variety of value added options for the C_4 stream. Some options reflect very simple approaches to the C_4 stream, (e.g., butadiene extraction and MTBE), whereas there are other options having additional complexity, including butene-1 extraction and other butylene derivatives. There is also considerable interaction with the refinery and the potential for blending refinery and petrochemical sourced C_4 streams.

1.1.2.1 Selective and Full Hydrogenation

Hydrogenation processes for the mixed C_4 stream are commercially available from Axens, UOP and Lummus. The product stream from full hydrogenation is a mixture of butanes and the product from selective hydrogenation is a so-called pseudo raffinate-1. The isobutylene content of this stream is about 20 to 22 percent (i.e., much less than in raffinate-1 from a butadiene extraction plant but higher than in a refinery sourced FCC C_4 raffinate). This stream is suitable
for isobutylene extraction and MTBE synthesis, but not certain grades of polyisobutylene which require a minimum of 35 percent isobutylene in the feedstream. This stream has a value between that of a petrochemical raffinate-1 and raffinate-2. Raffinate-1 is normally processed further to MTBE while raffinate-2 is mainly used in polygasoline and alkylation or processed further to produce butene-1. In more recent years raffinate-2 has provided a key feedstock for metathesis processes to convert contained butene-2 and ethylene into propylene.

1.1.2.2 Butadiene Extraction

Quantities of C₄ olefin byproducts are generated during the manufacture of ethylene by the steam cracking of hydrocarbons, particularly when naphtha or heavier feeds are used. Butadiene is extracted from this mixed C₄ stream using the principle of extractive distillation, since the relative volatilities of the various C₄ isomers are such that they cannot be separated by conventional distillation.

Figure 1.4  Overview of C₄ Processing
1.2 C₄ DEMAND DRIVERS

Nexant’s study will include a detailed assessment of global consumer markets for the C₄ stream and its purified components. This will include a full discussion of the industry structure and value chain in main consuming regions.

The C₄ stream contains a number of valuable products that are used as feedstocks for a range of important derivatives. Applications include synthetic rubbers, engineering resins, fibre intermediates and fuel additives. Special focus will be given to the developments associated with the automotive and tyre industries.

The important questions to address include the following:

- What is the global economic outlook and its impact of C₄ derivatives demand?
- What are the key development trends in the automotive and tyre sectors?
- Will future C₄ supply and processing capacity meet future demand?

The following figure depicts the historical price relationship between natural rubber and synthetic rubbers. A strong correlation exists between these products primarily due to similarities in performance for target applications. Nexant’s study will provide further insights into the natural rubber market along with longer-term pricing relationships with synthetic rubbers and discuss the impact and possibilities for material substitution in the tyre sector.
Figure 1.6  Natural Rubber and Synthetic Rubber Price
(2001-2011)

Source: Nexant
Section 2  
Report Scope

The objective of this report is to examine the current and developing fortunes of the C_4s market. The study will provide a thorough understanding of the C_4 value chain and focus on the following key aspects of the sector:

- Evolving feedstock slate capacity developments for regional ethylene production and resulting C_4 availability and production.
- Refinery integration and C_4 supply potential for the chemicals sector.
- Alternative routes to butadiene and production and relative competitiveness such as dehydrogenation and bio-based technologies.
- Emerging trends in the global automotive sector and tyre markets/technology.
- Sector market dynamics and pricing for butadiene, butylenes, and major derivatives.
- Future price projections for key components such as butadiene, synthetic and natural rubbers.

The study will provide a detailed 10-year history and 10-year forecast data.

The study was completed in October 2012. The cost of the study is US$20,000 (twenty thousand U.S. dollars).
Nexant will provide a detailed market assessment on a quantitative and qualitative basis. The analysis will include data covering supply, demand, production and operating rates.

For the key products defined below Nexant will provide the following:

- A narrative summary of market characteristics, prospects and rationale, major trends and drivers for growth in end-use sectors (e.g., automotive, etc.)
- Outline any major issues that may impact consumption growth such as material substitution, environmental or health and safety issues.
- A quantitative update of supply/demand and net trade by region and overviews of the global markets with regional breakdown.
- A summary of historic and forecast consumption, capacity, and operating rate, and implications for pricing.
- For each of the geographical regions, Nexant will carry out an analysis of the historical and forecasted total production capacity where known:
  - New capacity additions
  - Capacity rationalization
  - Operating rate assumptions

Nexant will provide a high level commentary for global and regional aspects of the market and describe its assumptions used in developing the various forecasts.
Market information provided in the study will cover 10-year history and 10-year forecast period for the following geographies:

- North America
- Europe
- Asia
- Middle East and Africa
- Rest of the World

Products addressed will include:

- Butadiene
  - Butadiene Rubber (BR)
  - Styrene Butadiene Rubber (SBR)
  - Acrylonitrile Butadiene Styrene (ABS)

- Butylenes
  - Butyl Rubber (IIR)
  - Methyl Tertiary Butyl Ether (MTBE)
  - Butene-1
  - MMA
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Methodology

4.1 PROPOSED APPROACH AND METHODOLOGY

Nexant has considerable experience in undertaking assignments of this type. The basic approach will be:

- Utilising experience from performing a similar role on a number of recent assignments.
- Utilising its global in-house databases on capacity/supply/demand/margins and pricing.
- Direct market research/fieldwork with end users, producers and other relevant bodies.
- Review of selected public domain sources to provide the latest view of market developments in selected countries.

Nexant has a strong track record in evaluating petrochemical markets. This experience, along with non-confidential information from previous studies, will be used for this study.

4.2 MARKET ANALYSIS: METHODOLOGY

Background

Market analysis developed by Nexant is compiled from external data – based on public domain information and industry interviews – by a comprehensive database engine that simulates global industry market dynamics, techno-economics and profitability for all key petrochemicals. This state-of-the-art Global Industry Simulator (GIS) builds on reliable data and proven models.

Already the industry leader in terms of its quality business planning consultancy (including profitability forecasting), the GIS has enabled Nexant to take a further leap forward. It has replaced over 10,000 spread-sheets and 25 databases and ensures a rigorous convergence on consistent sets of projections that satisfy all the influencing business rules. This is unique in chemical industry consulting, providing greater confidence in consistency. An overview of the GIS is shown in Figure 4.1 and general layout of data flow is shown in Figure 4.2.

The principal factors considered for Nexant simulations are as follows:

- Primary energy pricing (crude oil and natural gas prices, petrochemical feedstocks, power and utility costs).
- Economic growth (GDP growth projections; industrial, agriculture, automotive, construction, consumer spending and other sector projections; population growth).
- Currency exchange rate projections.
- Inflation projections – capital, wage and general inflation.
- Petrochemical asset development profiles (both planned and expected in the next four years and speculative addition/shutdown thereafter).
Due to the specific regional focus of this assignment Nexant will also conduct direct fieldwork in selected Asian markets were required. Nexant has a long history of working in Asian markets and has access to an extensive network of contacts throughout the region. Additionally, Nexant conducts annual field research on a global basis as part of its multi-client PPE Program and has an impressive contact base of suppliers and consumers within this sector.

**Figure 4.1 Global Industry Simulator**

Powered by a State of the art industry simulator that builds on reliable data and proven models.
Commodity chemicals profitability is heavily cyclical and shows close correlation with average industry operating rates. Periods of high returns have resulted from structural shortages. However, the sector is equally sensitive to the global economy and capacity additions, which can quickly reverse this situation. Current global demand growth rates will need to be sustained to ensure future capacity additions do not have an adverse impact on product margins.

Figure 4.3  Example Correlation of Operating Rate with ROI
Section 5  Contact Details and Subscription Information

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