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HDPE

PERP 09/10-3

Report Abstract
January 2011

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HDPE

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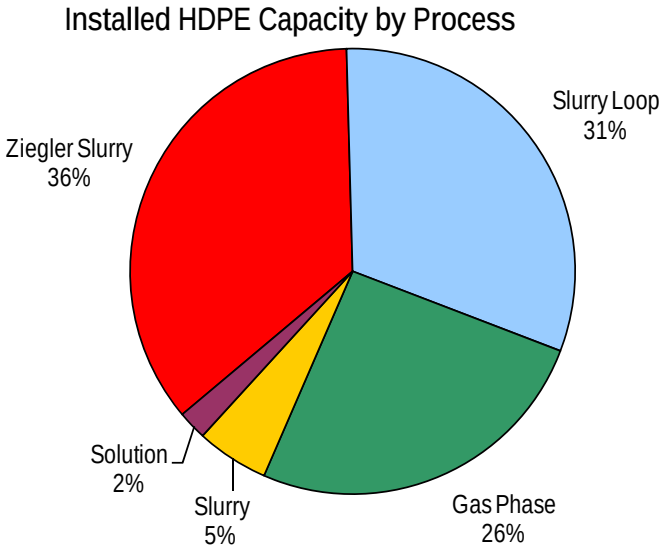
INTRODUCTION

High density polyethylene (HDPE) is a versatile polymer used in a variety of applications, including film (food packaging, retail bags, trash bags), blow molding (bottles, drums, gas tanks), pipe and conduit, injection molding (crates, housewares, pails), and fiber (woven bags).

The slurry routes (Ziegler slurry and slurry loop) to HDPE were the major processes prior to the introduction of the gas phase process in the early 1980s, and with it, the introduction of linear low density polyethylene (LLDPE) and the concept of the swing HDPE/LLDPE process. Although the gas phase processes have made significant inroads into the HDPE market, the Ziegler slurry and slurry loop processes continue to dominate installed capacity.



2010_00101.0010.4104_Section 1 Figures.xls\HDPE by Process

There is an increasing trend to bimodal products, where the combination of better processability without the loss of mechanical strength, permits downgauging, a reduction in product profile or thickness. For film, the same area of film can be made with less resin, while for pressure pipes, reduced wall thickness reduces raw material requirements and makes more flexible pipe. However, conventional unimodal HDPE will maintain a significant market share for those applications where the attributes of bimodal material are not required.

CURRENT TECHNOLOGY

The Ziegler slurry technologies employ dual reactors (in series) to produce bimodal product. High performance polymers require a resin with very few branches (comonomer) in the lower molecular weight fractions and high concentration in higher molecular weight fractions. Thus, sequential polymerization has been employed to control comonomer distribution, which is important for some resin grades, such as pipe and film applications. For this reason, these

processes remain a class of dedicated HDPE processes that serve a high-value end-use market not fully served by other processes that do not employ two reactors. A major development thrust has been to produce bimodal resin in a single reactor, with the focus on using a dual-site or mixed catalyst system, since single-site catalysts can dramatically change the branching distribution. Univation has recently commercialized its single reactor bimodal process, UNIPOL™ with PRODIGY™ catalyst.

The single loop slurry processes have dominated with respect to quality and performance of broad molecular weight distribution (MWD) resins for blow molding and pipe applications, as well as high quality medium MWD film resins. The advantages of the gas phase processes are a simpler process design, large single-line capacity, and wide product range.

Nexant evaluated various Ziegler slurry, slurry loop, gas phase, and solution processes that are well-established, commercially practiced technologies for the production of HDPE resin and are generally available for license. The evaluation provides recent developments; highlighting key developments relating to each process technology; background, including general product capabilities and a list of licensees; and a process description with simplified flow sheets, for each technology covered. The technologies discussed in this report are:

- Ziegler Slurry processes (dedicated HDPE)
  - LyondellBasell, *Hostalen* and Equistar-Maruzen
  - Mitsui, Mitsui CX
- Slurry Loop processes (dedicated HDPE and swing HDPE/LLDPE)
  - Borealis, BORSTAR®
  - Chevron Phillips
  - INEOS, INNOVENE™ S
- Gas Phase processes (dedicated HDPE and swing HDPE/LLDPE)
  - INEOS, INNOVENE™ G
  - LyondellBasell, SPHERILENE S and C
  - Univation, UNIPOL™ PRODIGY™ and UNIPOL™
- Solution processes (swing HDPE/LLDPE)
  - Dow Chemical, DOWLEX
  - DSM, COMPACT
  - NOVA Chemicals, SCLAIRTECH™ and Advanced SCLAIRTECH™

PROCESS ECONOMICS

Nexant developed and compared cost of production estimates for the major commercial HDPE processes using the U.S. Gulf Coast (USGC) as the basis. Cost estimates for film grade resin for bimodal HDPE were evaluated for the following processes:

- LyondellBasell, *Hostalen* ACP Ziegler slurry process with butene-1 comonomer
- Mitsui, Mitsui CX Ziegler slurry process with butene-1 comonomer

- Borealis, BORSTAR® slurry/gas phase process with butene-1 comonomer
- Chevron Phillips slurry loop process with hexene-1 comonomer
- INEOS, INNOVENE™ S slurry loop process with hexene-1 comonomer
- LyondellBasell, SPHERILENE C gas phase process with butene-1 comonomer
- Univation, UNIPOL™ PRODIGY™ gas phase process with butene-1 comonomer

Cost estimates for injection molding grade resin for unimodal HDPE were evaluated for the following processes:

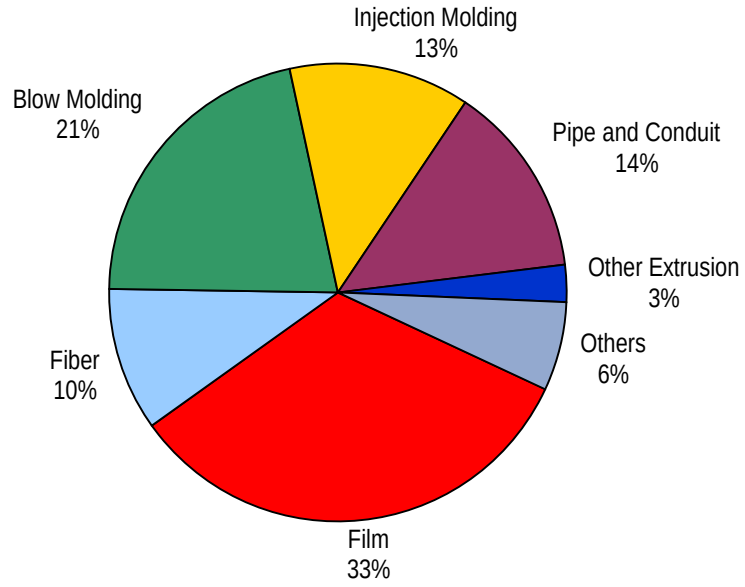
- Chevron Phillips slurry loop process
- INEOS, INNOVENE™ G gas phase process
- LyondellBasell, SPHERILENE S gas phase process
- Univation, UNIPOL™ gas phase process
- NOVA, Advanced SCLAIRTECH solution process

All 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

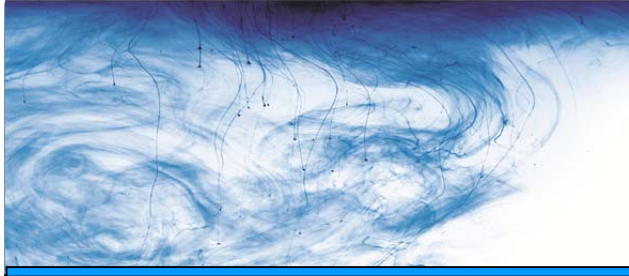
HDPE is used in many end use segments such as film, blow molding, pipe and conduit, injection molding, and fiber. For Asia Pacific, the end use pattern is quite a bit different than in the developed economies of the United States and Western Europe, where blow molding and injection molding dominate, and film and fiber are much less significant.

Asia Pacific HDPE Demand by End-Use



2010_00101.0010.4104_Section 1 Figures.xls\HDPE by Process

- Commercial applications are outlined in the report
- United States, Western Europe, and Asia Pacific demand, supply, and net trade data are given and discussed
- A list of plants in each of these regions is given showing company, location, current plant capacity, and technology employed.



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