Polymer-Modified Asphalt Supply Outlook

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DeWitt & Company
Acknowledgements

- Polymer Supply Information
  - De Witt & Company
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Predominate Modifier

- **Styrene–Butadiene–Styrene (SBS)** is most widely used in US and around the world
  - Excellent performance – case studies
  - Long history of success – since 1970’s in Europe
  - SBS produce a stable, compatible system easily used in today’s construction practices
Styrenic Polymers (Elastomers)

- Polystyrene is hard and brittle
- Commonly co-polymerized with butadiene

Polystyrene (S): Disposable fork
Butadiene (B): Rubber band

**POLY-STYRENE**

**POLY-BUTADIENE**
SB and SBS

Block Copolymer
(SB & SBS)

- Butadiene
- Styrene
Why is SBS Currently in Short Supply?

- Styrene-Butadiene-Styrene (SBS) polymer capacity is not short
- Shortage of raw materials - Butadiene
- Ethylene production is the problem
Why is Ethylene Production the Problem?

- By-products of Ethylene Production
  - Styrene
  - Propylene
  - Butadiene
  - Isoprene
  - Pentadiene
  - Cyclopentadienes
  - Aromatic Resin Formers
  - Isobutylene
  - Amylenes
  - Hydrogen
  - Benzene
Ethylene & Butadiene Market Comparison

- **Ethylene Market**
  - 120 million tons per year
  - Primary use – packaging materials
    - Plastic wrap
    - Trash bags
    - Milk jugs

- **Butadiene Market**
  - 14 million tons per year
  - Primary use – tires (70%)
  - Multiple other automotive and durable good uses
  - SBS polymer for asphalt (6%)
Basic ethylene production technology is called a steam cracking process
- Process heats feed up to 1700 degrees, then injects steam that cracks the molecules
- Cracker unit cost $2 billion

Choice between gas feeds like ethane, propane and butane and liquid feeds like naphtha and gas oils.

Output is a mixture of ethylene and other products

Requires a downstream purification processes to separate products
What’s Important to Know About Ethylene Production

Steam Cracking Process

- Ethylene
- Propylene
- Benzene
- Butadiene
- Pentadiene
- Isoprene
- Cyclopentadiene
- Aromatics

Produced by both Gas and Liquid Feed

Only a by-product of cracking Liquid Feeds

Gas Feed

Liquid Feed
Choosing Feeds to Produce Ethylene

- Each producer runs an economic model
- Feed availability and costs for the producer at their location
  - Yield of each feed – varies considerably
  - Demand for each product
  - Alternatives to buy versus make that product
- Ethylene and propylene are the prime products
  - Evaluate netback of all products
  - Liquid feeds generally produce 15:1 ethylene to butadiene
  - Economic impact of butadiene is not large
  - Based on the conditions producers set a feed slate for the “Cracker”
  - Butadiene shortage is not a primary consideration for feed slate
Liquids are always in the slate due to the facilities being built to be liquid crackers

Crackers modified in the 80’s to be flexible

Flexibility depends on producer, but varies from ~10% to ~50%

Producing 3-5 million pounds a day a few pennies makes a big difference
What’s Changed

- Structural change - natural gas producers installed facilities to separate ethane
  - Ethane higher value than natural gas
- Ethane prices didn’t increase with the crude oil run-up
- Economic incentive to run more ethane feed
DeWitt estimates that the 1Q cracking slate went 10% lighter vs 2007 starting in February

2Q2008 slate has moved even lighter; possibly another 10-20%

Incentives so great that teams of engineers are working on putting more gas into the cracking slate on a crash basis
July 2008

Ethylene Cash Costs, c/lb
Ethylene General Trends

- Significant ethylene capacity additions in Middle East and Asia
  - Most of the Middle East is gas cracking
  - Most of Asia is liquid or naphtha cracking

- Little to no capacity additions in Western World

- New trend for ethylene units outside of US to be more flexible to be able to run more gas feeds
  - Historically have been naphtha crackers

- Expect more flexible cracking; hence, more variable Butadiene supply
Butadiene (Bd) Supply

- Globally tight due to lighter cracking and higher demand
  - 2008 Bd supply estimated at 75-85% of 2007

- New Bd and ethylene capacity due on-stream in Asia

- Expected capacity utilization to be lower than 90% for the foreseeable future

- Regional differences
  - US crude Bd supply tight due to light cracking in first half
  - US has excess purification capacity and buys crude Bd from Europe to fill capacity
  - Europe tight on supply due to somewhat lighter cracking; thus, less crude Bd to export to US
  - New Asian capacity needs to catch-up with demand
North American Butadiene Consumption

- SBR (crumb form) 28%
- SBR Latex 12%
- Poly-chloroprene Rubber 2%
- Nitrile Butadiene Rubber 3%
- Acrylonitrile Butadiene Styrene 5%
- Adiponitrile 13%
- SBS (For Asphalt) 6%
- Other 3%
- Poly Butadiene Rubber 28%
## What Factors Will Influence Supply?

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<tr>
<th>Positive</th>
<th>Negative</th>
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<tr>
<td>- New capacity</td>
<td>- Higher natural rubber prices driving consumers to synthetic rubbers based on Bd</td>
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<td>- Bd pricing itself out of some applications</td>
<td>- Lighter cracking</td>
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| - High gas prices:  
  - Less driving mean fewer replacement tires  
  - Smaller vehicles/smaller new car tires | - Higher naphtha prices  
- Structural change in US ethane market |
| - Slowing economy; less growth | - Low cost gas-based ethylene capacity coming on-stream in Middle East. |
Tire Demand Data

- **New Tire Demand**
  - June vehicle production down 8% and falling
  - Vehicle production skewed towards smaller vehicles
  - Tire demand could be down over 12%

- **Replacement Tires**
  - Higher gas prices are reducing miles driven
  - Expect reduced tire demand over time
  - May take 3-6 months to play out.
October 2008

- Spread between gas and liquid feeds now down to $.05
- Demand is shrinking – tire demand is down
  - Asian market price drop of $0.10- $0.15 per lb
October 2008

- **Hurricanes Gustav and Ike** – temporarily shut down Gulf Coast crackers
  - Expected Bd price increase of $0.10 per lb
  - Reduced demand caused spike of only $0.04 per lb
- **Crackers are back on line, but tire compound plants are not**
- **Tire Demand is way down** – Frees up Butadiene for SBS Suppliers
  - Result – **100% Bd available to SBS producers for now**
  - SBS suppliers will be able to build up substantial inventory this winter
Alternatives to SBS Polymer

- SBS polymer-modified asphalts are typically cross-linked systems
  - Contractor friendly
    - Terminal blend supply
    - Do not require agitation
    - Storage stable
    - No major changes to HMA plant operation
    - No major changes to HMA laydown and compaction
- Alternative modification systems should exhibit similar qualities
Alternatives to SBS Polymer

- **SBR Latex** – butadiene based polymer that is not in short supply at this time
  - Not storage stable
  - Must be blended at HMA plant
  - Contractor now becomes asphalt modifier and must test and certify product

- **Non- butadiene polymers**
  - Reactive Ethylene Terpolymer (Elvaloy)
  - Ethyl Vinyl Acetate (EVA)
    - Used in warm climates
    - Blended with SBS in cold climates

- **Polyphosphoric Acid (PPA)**
  - An extender, not an alternative
  - Can be blended with SBS to reduce SBS content
Alternatives to SBS Polymer

- **Ground Tire Rubber (GTR) – wet process**
  - 15-20% GTR melted and swelled into asphalt
  - No cross-linking occurs
  - Not storage stable
  - Not a terminal blend process
  - AR binder cannot be PG graded in a meaningful way
  - Recipe specification

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The image shows a machine used in the asphalt process, likely related to the application of ground tire rubber.
Alternatives to SBS Polymer

- **Ground Tire Rubber (GTR) – terminal blend**
  - Typically proprietary process
  - 10-12% GTR added at high temperature and processed with high shear milling
  - Chemical stabilizer added
  - 70% of GTR is non-rubber material
    - Carbon black
    - Calcium carbonate
  - Settlement may be an issue
  - SBS is sometimes used to stabilize the system
  - Cannot be PG graded under current DSR test procedures
Alternatives to SBS Polymer

**Hybrid Binders**
- Blend of SBS and GTR
- Cross-linked system
- Storage stable
- Terminal blend system
- Current research sponsored by FL DOT at University of Florida
Alternatives to SBS Polymer

- ‘NOTHING’ is not an option
  - PG Grading system is based on climate and traffic
  - Using the wrong grade will lead to poor performance
  - We have enough historical data to prove that PMA does improve pavement performance
  - Flexibility and creativity are needed to come up with answers
DON’T SHOOT THE MESSENGER