SBS Polymer Supply Outlook

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Forecast – February 2009

As noted in this update to this white paper, it has become apparent over the past few months that there will **not** be a shortage of butadiene this year, and that, as a result, the supply of SBS for calendar year 2009 should be adequate. It is currently a very volatile economic climate and things can and do change fast. However, as of right now, there should not be shortages in the supply of either butadiene or SBS for the 2009 paving season.

Introduction

There was a shortage of styrene-butadiene polymers for the asphalt industry in 2008. The shortage involved a variety of polymers, including linear and radial SBS polymers, and diblock SB polymers. These will all be abbreviated below as 'SBS'.

AMAP has, with the help of De Witt and Company, investigated this issue and has written this paper in an effort to explain the factors driving potential SBS polymer supply shortage and to provide some outlook for future supply. The intent of this paper is to help the HMA industry understand the situation and to cope with it.

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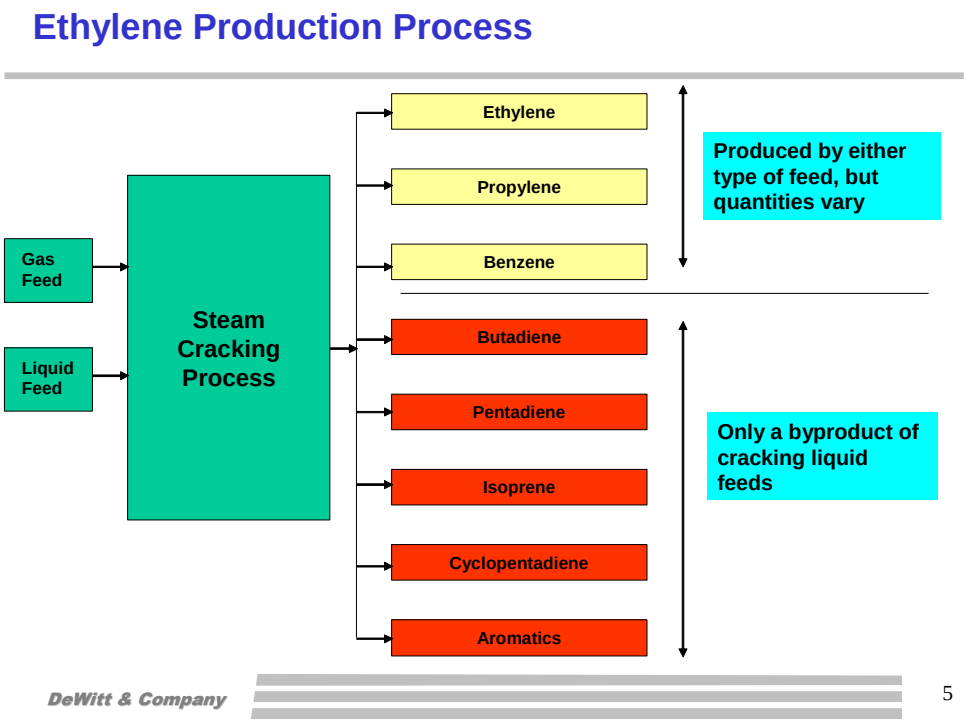
Background

In order to understand the problem with SBS polymer shortages in 2008, it is critical that we first understand the supply chain. The proximate reason for shortage of SBS polymer was a shortage of butadiene. Butadiene is not produced on purpose, but is a by-product of the production of ethylene. Many chemicals, including styrene and butadiene – the two basic building blocks for SBS polymers – are obtained as by-products from ethylene production.

Ethylene is made via a steam cracking process, and it is one of the many products resulting from the process. Operators of these "crackers" can either feed a gas such as ethane, butane and propane or can feed a liquid petroleum product such as gas oil or naphtha into the process as the raw material. As the chart below shows, ethylene, propylene and benzene can be produced from either gas or

liquid feed. However, butadiene and the other chemicals appearing in the flow diagram beneath the butadiene are produced *only* as a byproduct of cracking liquid feeds.



Cracker operators use economic models to determine the feed slate. Gas feeds, especially ethane, were less costly than liquid feeds in early 2008. The cost to produce a pound of ethylene in May 2008 using ethane feed was $.50 compared to a cost of $.70 per pound when feeding naphtha. As a result, cracker operators were running more gas feeds and producing lees butadiene. The cracking slate moved 10% towards lighter products in the 1st quarter of 2008 and continued this move in the second quarter. Incentives to continue to move to lighter feed products continued to be great, and processors were working to put more gas into the cracking slate on a crash basis. Lighter feed slates resulted in less butadiene production. Butadiene production in 2008 was projected to be approximately 70-75% of 2007 production.

General trends in the ethylene market are as follows:

- The worldwide ethylene market is 120 million tons per year
- The primary use for ethylene is product packaging
- There are scheduled significant ethylene capacity additions in the Middle East. Most of the Middle East is gas cracking (no additional butadiene)
- There are new crackers being built in Asia. Most of the new capacity in Asia is liquid, or naphtha cracking.
- There is scheduled little or no capacity expansion in the West.
- Naphtha is short globally, and expected to carry higher prices until new refinery capacity in Asia and the Middle East comes on stream, around 2012.
- New cracking units are tending towards greater flexibility, i.e., able to handle both gas and liquid feed. This will lead to less predictable butadiene supply.

General trends in the butadiene market are as follows:

- The worldwide butadiene market is 14 million tons per year
- The primary use of butadiene is in tires (70%)
- SB and SBS polymer for asphalt modification accounts for 6% of butadiene usage
- US crude butadiene supply was tight due to light cracking in 1st half of 2008.
- US has excess purification capacity and buys crude butadiene from Europe to fill capacity.
- Europe is tight on supply due to lighter cracking, resulting in less crude butadiene to export to the US.
- New Asian capacity needs to catch up with demand.

Conclusions

A number of factors will influence future butadiene supply. Negative factors influencing future butadiene supply are as follows:

- Lighter cracking will lead to more production flexibility and potentially less butadiene productions.
- Low cost, gas-based ethylene cracking capacity in the Middle East will result in no net additional butadiene availability.
- Higher naphtha prices and structural changes in the US ethane market will lead the industry to lighter cracking and lessened butadiene availability.

Positive factors influencing increased butadiene production are listed as follows:

- New butadiene capacity in Asia will bring some relief.
- Higher butadiene prices will drive butadiene out of some applications, thus easing supply problems.
- High gasoline prices and a slowing economy have reduced demand for new vehicles and new tires. High gasoline prices have also shifted vehicle sales away from trucks and SUVs to smaller, more fuel efficient cars. These small cars will require smaller tires, thus reducing butadiene demand. Car sales in July 2008 were down 20% compared to July 2007. The shift to smaller tires should reduce butadiene demand even more. It will take time for the reduced demand to work its way up the supply chain, but in time it will provide additional butadiene to the asphalt market.

The costs of gas and liquid feeds for crackers are subject to change rapidly as the price of crude oil fluctuates. The cost of ethane rose to a level equal to the cost of naphtha in July 2008, but the cost of propane remained significantly less. The result was the availability of SBS polymers remained tight for the first three quarters of 2008..

Update - October 2008

Recent global developments have significantly changed the short term outlook:

- The drop in demand for tires resulting from reduced driving has taken place.

- The differential in cost to produce ethylene from liquid fuels compared to the cost of ethylene production from gas has significantly narrowed, from a premium of approximately

$0.20/Lb. in July 2008 to a current differential of about $0.05. This will encourage a heavier cracking slate, which will produce more butadiene.

- The impact of hurricanes Ike and Gustav on butadiene prices had been lower than anticipated. Where one might have expected a spike in the range of $0.10 per lb. of butadiene as a result of production disruptions in Gulf Coast facilities, the actual number has been less than $0.05. We speculated that the reason for this is a softening in tire demand.

- Crackers in the Gulf Coast were now back in production following the hurricane cleanup, but some of the facilities that use butadiene to manufacture compounds for tires are not yet reopened, possibly due to large existing inventories of product. This has freed up butadiene supply for SBS manufacturers. As of October 2008, SBS manufacturers were no longer on butadiene allocations and were receiving 100% of their butadiene needs.

We anticipate that this will give SBS producer greater access to the raw material, and the ability to build inventory in the coming months in anticipation of the 2009 paving season.

Update – February 2009

The world-wide economic slowdown has caused ethylene demand to drop 10 -20%, but the drop in tire demand is causing the butadiene demand to drop even more. Manufacturers will ramp down production of ethylene, but the overall production of butadiene will be ample to supply the needs of both the tire manufacturers and the SBS suppliers. **The supply of SBS for the 2009 paving season appears to be ample at this time.**

AMAP suggests the following list of modifiers as possible alternatives to SBS polymers during any future SBS supply shortage:

- Styrene Butadiene Latex - SBR latex has been used extensively in the paving industry as an elastomeric modifier for asphalt, and although it has similar elemental chemical composition to SBS, it did not suffer from a severe shortage in 2008.
- Reacted Ethylene Terpolymer (Elvaloy)
- Ethyl Vinyl Acetate (EVA) – EVA modified asphalt can be subject to cracking in cold-weather climates. It can be used alone successfully as a modifier in warm climates or it can be blended with SBS to provide reasonable cracking performance in cold weather.
- Ground Tire Rubber (GTR) – the wet process is a recipe specification that adds 20% GTR to asphalt and allows it to melt and swell. However, no cross-linking occurs and the binder is not storage stable. It should also be noted that the rubber particles in this material prevent a meaningful PG grading in the Dynamic Shear Rheometer.
- Hybrid Binders – the SBS supply can be extended by blending SBS with GTR to produce cross-linked storage stable polymer-modified asphalt
- Polyphosphoric Acid (PPA) - PPA has been used successfully as a co-modifier/extender in conjunction with SBS polymer and as a catalyst/co-reactant with Elvaloy