THE HIGH PRICE OF BUTADIENE

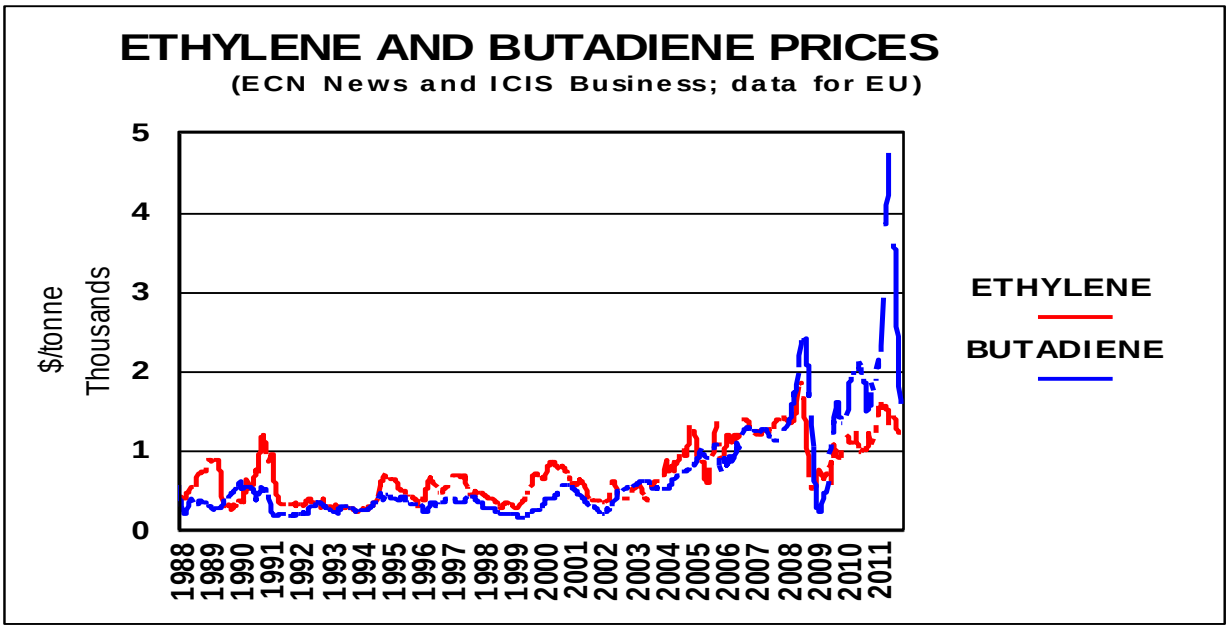
There is a business opportunity to satisfy the increasing demand for butadiene. The main issue to be addressed is the high capital cost for the dehydrogenation of butane or butene and the separation of butadiene. There are clearly opportunities to lower this cost by finding alternative routes, possibly by re-engineering of older and largely abandoned processes which use ethanol or acetylene as the starting material.

Key Words: price, ethylene, butadiene, ethanol, acetylene, feedstock, ethane, naphtha, propane, butane, gas oil

The Price of Butadiene[1]

At this present time, the price of butadiene is reaching historical highs, typically over $2000/t and sometimes over $3000/t when only about 5 years earlier the price was less than $1000/t . The figure below shows the reported butadiene spot price for the last two decades. For comparison the figure also includes the price of ethylene; this is further compared in the second figure which gives the ratio of the butadiene and ethylene price.

Figure 1



[1] Butadiene is 1,3-butadiene: CH2:CH.CH:CH2

Figure 2

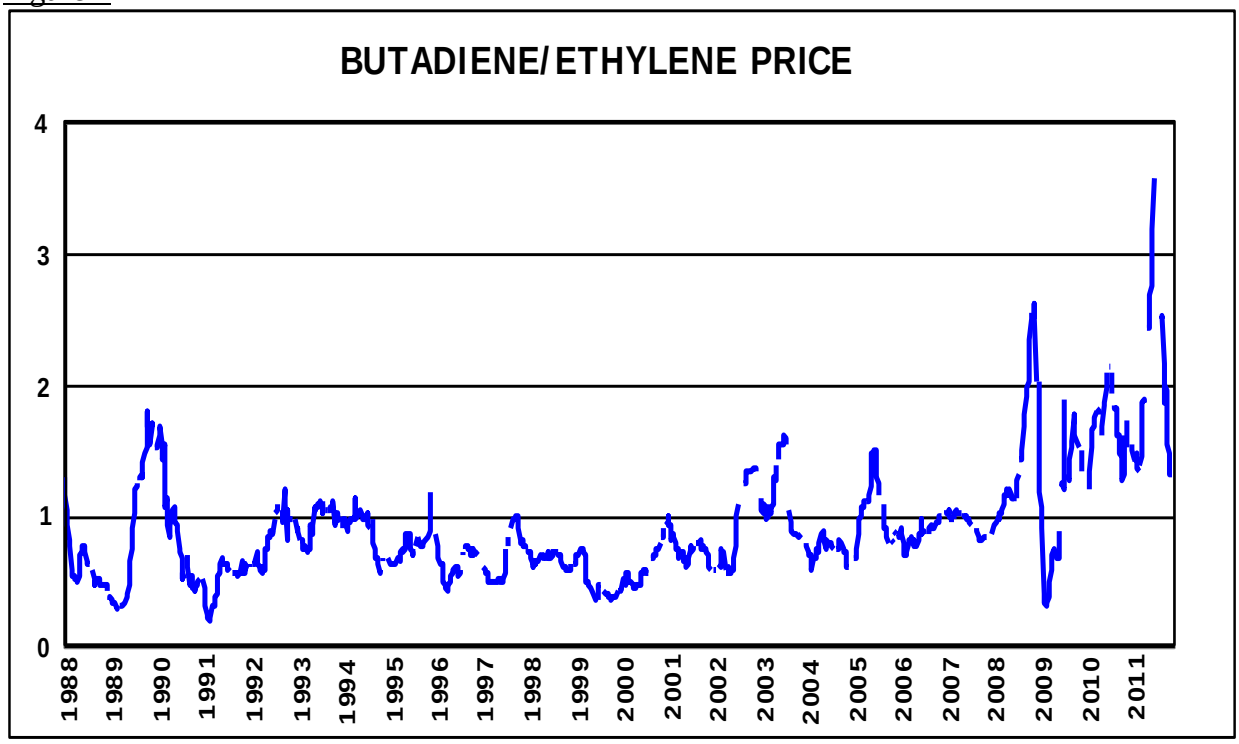


Figure 2 illustrates that the dramatic rise in the price of butadiene relative to ethylene is a recent phenomenon. Prior to about 2003 the value of butadiene ($/tonne) terms was generally less than that of ethylene (price ratio <1) and sometimes was only half the ethylene value. In this period the supply of butadiene was plentiful and generally satisfied from the cracking of naphtha and other heavy liquids in steam cracking operations.

From about 2003 to 2008, there was a steady rise in the price of butadiene and ethylene, with the relative value of butadiene to ethylene rising slightly so that at the end of the period the prices were similar.

The price volatility in 2008 as a consequence of the GFC saw butadiene prices rising to over $2000/t. However, since 2009, butadiene prices have skyrocketed, at one point reaching over $4000/t, and since this time the price of butadiene has persisted at higher than 50% of the price of ethylene.

Supply

One of the principal underlying factors is the restriction in the supply of butadiene relative to demand. Supply is mainly from the steam cracking of naphtha and gas oil, with a small portion coming from butane dehydrogenation.

In a naphtha (or gas oil) cracker as well as ethylene and propylene, there is a significant quantity of C_4 stream produced, which is rich in butadiene. However, lighter feedstocks produce less

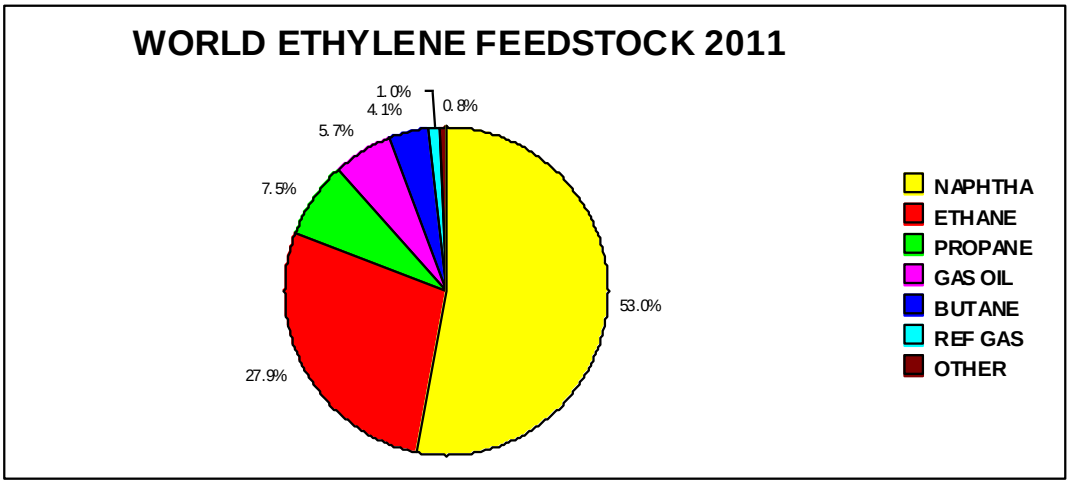
butadiene. The pertinent yields from various cracker feedstocks is shown in Table 1; the butadiene (BTD) yield is about have the value of the total BTD and C_4 olefin yield. The data illustrates that ethane and propane produce significantly less butadiene (and other C_4 olefins) than butane, naphtha and gas oil.

Table 1: Yield of ethylene, propylene, butadiene and C_4 olefins from various feedstocks

	ETHANE	PROPANE	BUTANE	NAPHTHA	GAS OIL
Ethylene	76.80%	44.29%	44.33%	30.19%	20.17%
Propylene	2.61%	13.73%	14.89%	15.46%	14.48%
BTD/C_4 olefins	2.61%	3.99%	6.65%	7.67%	7.95%

The current world feedstock used in ethylene crackers is illustrated in Figure 3[2]. For the most part, steam cracking is dominated by naphtha as a feedstock with most of the rest being ethane with minor contributions from propane and gas oil. However, this has progressively changed over the past decade. Because their value as fuels in their own right, the price of propane and butane (LPG) has risen relative to crude oil, propane and butane (LPG) have become less favoured as cracker feed. Furthermore, increasing volumes of ethylene are being produced from ethane cracking rather than heavier feedstocks such as naphtha. This is especially so in the Middle East where very large ethane cracking plants have been commissioned. This shift in feedstock has served to reduce the relative proportion of butadiene available, and constricts the supply.

Figure 3



[2] Data from extracted from "International Survey of Ethylene from Steam Crackers", *Oil & Gas Journal*, July 4, 2011

Demand

The principal use of butadiene is for the production of SBR (styrene-butadiene rubber), PBR (poly-butadiene rubber) and ABS (acrylonitrile-butadiene-styrene) thermo-plastic resin. SBR and PBR are used in tyres and ABS components are widely found in automobiles. Thus, although the automotive industry in the OECD countries has had problems in the pact few years, growth in demand and automobile production in Brazil, Russia, India and China has more than compensated.

So demand for butadiene has increased at a time that supply has become more restricted and hence the rise in price.

Has this feedstock-shift affected other commodity chemicals?

The shift in cracker feedstock from naphtha to ethylene would be expected to cause problems with other commodity chemicals. Generally this is not as pronounced as in the case of butadiene as there are supplies from alternative routes.

Propylene

Propylene supply is satisfied by the increasing use of refinery fluid-cat-crackers (FCC) as a feedstock source. A typical refinery FCC unit produces about 5% propylene as by-product to the production of gasoline and light diesel blendstock; this propylene has traditionally been used for the production of alkylate and poly-gasoline. Alteration to the catalyst formulation can produce more propylene which is increasingly being purified for polymer production. Furthermore, in many parts of the world propylene is produced by propane dehydrogenation. The result is that although propylene demand has risen the relative price rise has been moderated by increasing supply from other routes.

BTX

BTX (the aromatic compounds: benzene, toluene and xylene) supply is also affected by the move away from naphtha as a cracker feedstock. There has been a significant rise in the value of BTX but this is moderated by BTX product from other sources. One of these sources is pyrolysis gasoline which is produced by naphtha steam cracking. Over the past decade, the use of pyrolysis gasoline is no longer in favour as a fuel blend component (too much benzene) and more of the world's naphtha cracking operations have added a BTX recovery plant, thereby increasing world supply. Furthermore, BTX is produced from naphtha reforming in refineries and more stringent limits to the aromatic content of gasoline has made more BTX available for the chemicals industry.

Conclusion

Clearly there is a business opportunity to satisfy the increasing demand for butadiene, which is likely to persist. The main alternative technology is butane dehydrogenation route with the main

issue to be addressed being the high capital cost of dehydrogenation and separation of butadiene; butadiene separation is a complex process involving extraction and distillation of the raw product streams. There are clearly opportunities to lower this cost by finding alternative routes. Some of these routes could be based on older, now largely abandoned processes.

There are several processes which use acetylene as a feedstock. Acetylene can be produced from coal or natural gas. One acetylene route goes via acetaldehyde as an intermediate which can also be made from ethanol, and hence a potential route from renewable sources.

Another process which uses ethanol (the Lebedew process) uses ethanol feedstock which dimerises, dehydrogenates and dehydrates the ethanol in a single step.

Another acetylene process (Reppe process) acetylene and formaldehyde are combined to produce 1,4-butanediol. This can be dehydrated to butadiene.

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