

Are oil-based petrochemicals only a short-term phenomenon?



Pigments produced in China by Keck-Chemie

The major synthetic chemical industries only came into existence in the mid-19th century in Britain and so have had a relatively short life. By the end of the century growth was being led by research and expansion in Germany. There were many areas of development, but of particular interest to the footwear industry was the research and production of materials for the dye industry, followed by the introduction of synthetic polymers.

We now think of the polymer and pigment chemical industries as being totally dependent on oil-based products. This is because petroleum can be easily cracked to produce ethylene and propylene, which can then be used as clean, simple feed-stocks to manufacture a wide range of chemical and polymer precursors. However, prior to the 1950s, when petroleum-based products started to monopolise the market due to their ease of use and lower cost structure, coal-based materials still dominated as they had from the 1850s, offering 100 years of development, technology and production skills.

Why did this change?

Oil-based products are easy to produce as essentially monomeric species such as ethylene and propylene. The processing of coal leads to a complex mixture of mainly cyclic chemicals such as benzene, which are contaminated with sulphur and nitrogen compounds. Therefore, when oil became a source of raw material that was comparable or cheaper than coal-based sources, there was no competition and it essentially took over the whole market.

This position has not been significantly disturbed by the many spikes in the price of oil since the 1970s, as even if it stayed higher, it always dropped off from the top of the peak level. However, the situation has now changed dramatically with the latest round of oil price increases and a world that appears to be moving towards continually rising levels due to greatly increased demand and a reduction in supply over the long term.

Most oil production is supplied by 'old' fields with 70% coming from fields that have been producing for 30 years or more, and about 20% from truly 'giant' fields which were mainly discovered in the 1950s. By definition the remaining 80% are not giants, although a few are large. These relatively

smaller fields will reach their halfway point (peak of production) sooner than the giants and, the greater the demand, the sooner these medium and small fields will peak. This means that giant fields with high pumping capacities are of crucial importance in meeting world demand.

There are no giant fields left to find as oil companies have spent billions on superior technology in trying to find them. They now appear to be unwilling to continue the search and the number of exploration rigs has fallen dramatically. While more fields will come on stream, they will all be relatively small fields by comparison.

Oil is becoming more scarce

The world consumed 25 billion barrels of oil in the year 2000. By 2004, this had risen to about 30 billion barrels. At this rate, all existing global oil reserves will be gone in less than 40 years. Oil is added to reserves as new medium-sized and small fields are found, but the rate of draw off from existing fields is such that for every barrel of oil added to the reserve pool, three are withdrawn.

On the other hand there are still significant deposits of coal around the world and, without further exploration, the known sources have a predicted lifetime of around 170 years at the current rate of usage. The price of oil and gas has risen significantly over the last year and, whilst coal has not been immune to this price pressure, it is now a significantly cheaper source of energy than either of the other two.

Energy costs for coal, oil & gas					
	Coal		Oil		Natural Gas
Price Raw Material	\$10/tonne	\$40/tonne	\$20/barrel	\$70/barrel	
Coal (\$/mBtu)	0.4	1.5			
Oil (\$/mBtu)			3.5	12.0	
Natural Gas (\$/mBtu)					2.0 7.0

When oil was \$20/barrel (\$3.5/mBtu) and gas \$2/mBtu (\$0.4/mBtu)—even though coal was cheaper—the difference in price was not sufficient to overcome the inherently greater difficulty in handling complex coal-based chemical products. Now the price differential has more than trebled, coal is once again becoming an attractive source of chemical feed stocks with the price advantage outweighing the difficulties of ➤

Chinese capacity (Ktonnes) & actual (Ktonnes) 2005 production for PVC

	Capacity 2005	Capacity 2006	Capacity 2007	Prod 2005
CaC ₂ & HCl	6,472	8,950	10,190	5,818
Imported VCM	615	195	195	550
Ethylene & Imported EDC	1,510	1,610	1,830	1,197
Captive Ethylene & Chlorine	1,080	1,910	1,910	728
TOTAL	9,677	12,665	14,125	8,393

processing it.

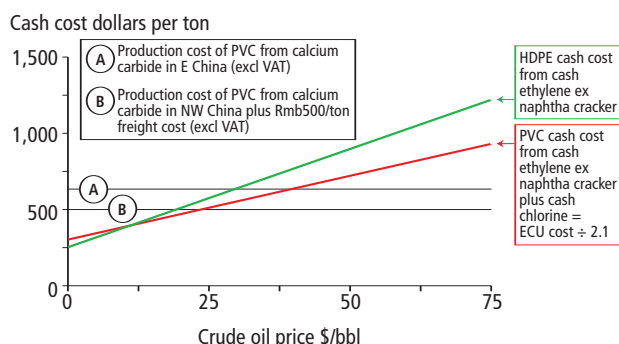
An example of the effect of the price of oil relative to coal-based chemicals on the cost structure of polymers can be seen by looking at the production of PVC which, despite all of its negative environmental concerns, is still a major material for the footwear industry.

VCM & PVC

There are two routes for the production of vinyl chloride monomer (VCM). The initial route that led to the introduction of VCM and PVC in the 1950s-60s was based on acetylene derived from coal. This was replaced by the ethylene route obtained from oil that became increasingly favoured in the 1970s-80s. The superior economics of the ethylene route then led to the progressive closure of acetylene-based plants, with the last one in Western Europe closing in the mid-1990s and in the USA a few years ago. The acetylene route seemed destined to disappear entirely but has had a remarkable renaissance in China over the last few years, as coal-based products have become more economically effective.

Most of today's production of VCM in China is not through the usual route of the combination of chlorine with ethylene to make ethylene di-chloride (EDC). Instead, it is through the conversion of coal to calcium carbide, which takes place near to the coal mine. This is used to make acetylene locally, which is then combined with HCl from a local chlor-alkali plant to make VCM and then PVC. The costs of production of PVC in China are shown in (Figure 1):

Figure 1: Production cost: dependence on crude oil price international PVC, HDPE vs PVC (ex acetylene) in China



Line A is the cost of production of PVC in the eastern provinces using calcium carbide which has been brought by lorry from factories in the north west.

Line B is the cost of producing PVC in the north west of China, near the mines and where coal is cheap. It also includes the cost of freighting the finished PVC to user industries along

the eastern seaboard.

These two lines are horizontal, since it is considered that the coal price in China is effectively constant and not influenced by international crude oil prices.

The lower sloping line (red) represents the cost of production of PVC from ethylene that has been produced from naphtha and includes the average cost of freight to an eastern China port. Since naphtha is a world commodity, this line approximates to conditions in many parts of the world.

It is clear that international PVC cannot compete with Chinese PVC made on the east coast unless the oil price is below \$35/bbl and cannot compete with PVC made in the north west, unless oil prices are below about \$25/bbl. With crude oil prices currently around \$70/bbl, it is understandable why exports to China are falling and equally that exports of PVC by China are starting to emerge.

The higher sloping (green) line illustrates the cost of production of high density polyethylene (HDPE) from naphtha-based ethylene. It is seen that when crude oil prices are above \$50/bbl, HDPE becomes considerably more expensive to produce than PVC.

Transplant of European production to China

As footwear production has shifted from Europe to China, several European suppliers of machinery, chemicals and components have followed the market and set up satellite operations in China, either as stand-alone entities or joint ventures. Just one example, Jakob Keck Chemie GmbH, illustrates the double advantage that such a move offers and the increasing strength of coal-based chemicals.

The company has been active in the footwear industry for over 100 years making a broad range of lacquers, paints, adhesives, colour pastes and mould releases. It has production units in Germany, France, Spain and Pakistan, plus extensive R&D facilities in Germany. In late 2002 it opened a satellite production factory in China with the intention of importing key materials from Europe in order to carry out blending locally in China. However, it quickly found the cost of raw materials in China was so much lower than in Europe that they could begin to switch to full production in China and ship concentrates back to Europe.

The company was initially suspicious of the extremely low costs. Organic pigments for example were only 25-30% of equivalent products in Europe. What it found was that it was not only the lower cost of labour that led to lower prices but also the fact that they were produced from coal-based chemicals. It now sources a large part of its pigments, resins and polymers for the Chinese production from the local Chinese market and sees this as a long-term driver to ensure the profitability of its global business.

It is quite clear that as long as oil stays at or above \$70/bbl, the future resurgence of a coal-based chemical industry is looking very good. China, due to its continued use of coal-based products through its development stage over the last 30-50 years, is particularly well-placed to capitalise on this growth. 🌱

Data and graphs by permission of Charles Fryer, Tecnon Orbichem Ltd, taken from two papers given at the Asia Petrochemical Industry Conference, Bangkok, in 2006.