CHEMICAL ECONOMICS - NEW COAL CHEMISTRY

In the beginning of the industrial revolution, the chemical industry was based on coal as the principal feedstock and more particularly coal tars and liquors produced from low temperature coal gasification to produce town gas. The second oldest Australian company (AGL) had its origins in this industry - town gas from coal. After the second world war, coal as a feedstock was replaced by oil and this era saw the development of large scale technologies for the production of petrochemicals. Nowadays, industrial chemicals based on coal is rare, except that is in China where a revolution in the use of coal as a chemical feedstock is taking place.

The new technologies, principally discovered and developed in the western world, are now being commercialised on a massive scale in the far west of China where abundant deposits of coal are to be found. The process involves multi-step routes to produce firstly synthesis gas by gasification of coal in advanced gasifiers. These units convert the coal into synthesis gas, which is a mixture of carbon monoxide and hydrogen using a mixture of oxygen and steam. Gasification is a complex process; the simplified stoichiometry is:

$3C + H_2O + O_2 = 3CO + H_2$

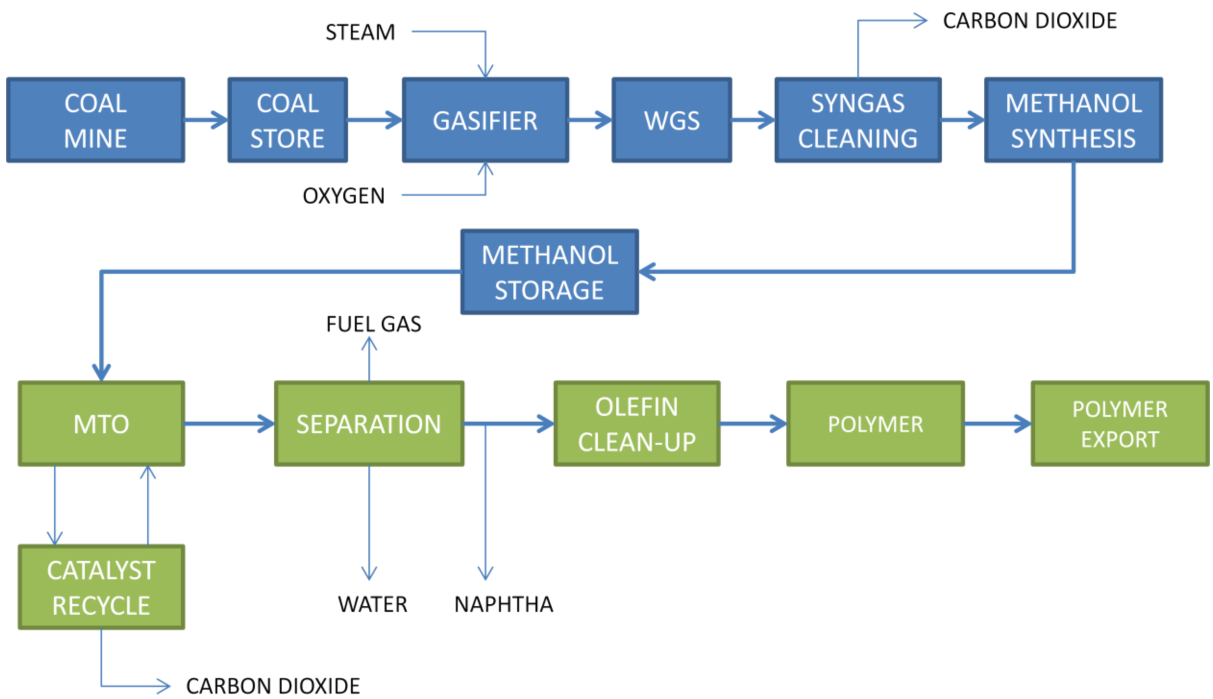
Water gas shift, both within the gasifier and in a downstream unit concerts some of the carbon monoxide into hydrogen:

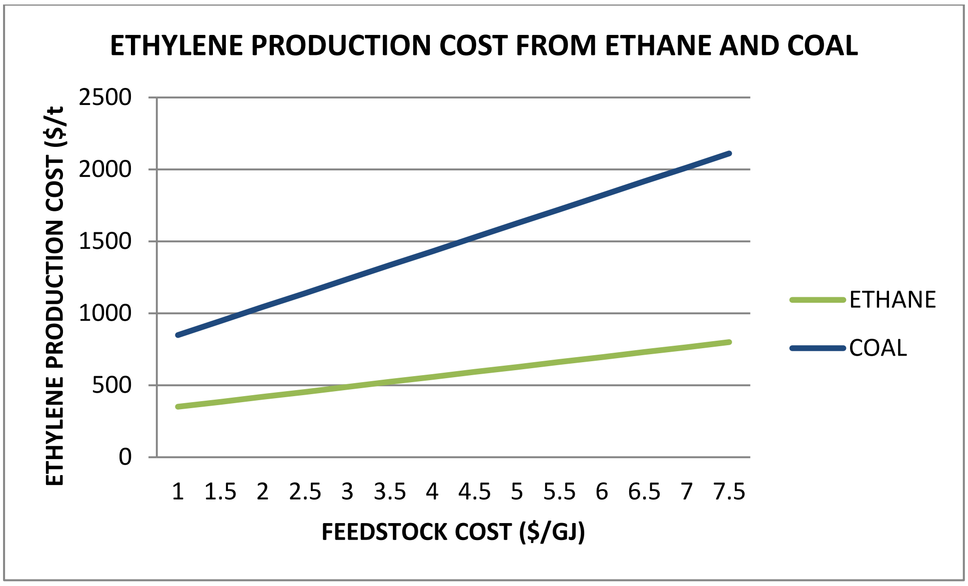
$CO + H_2O = CO_2 + H_2$

After cleaning and removal of carbon dioxide the final synthesis gas has two moles of hydrogen per mole of carbon monoxide. Synthesis gas of this composition can be used for the Fischer-Tropsch process to produce fuels and chemicals as practiced in South Africa and elsewhere using natural gas as a feedstock. The new technologies, however, convert the synthesis gas to methanol from which olefins can be made using molecular sieve catalysts. There are two processes, one produces ethylene, propylene and some butenes, whilst the other process produces only propylene as the olefin product.

The main unit operations are shown in Figure 1. A typical coal to olefins plant will use 5 million tonnes (Mt)of coal to produce about 1.67 Mt methanol which is used to produce about 600kt of olefinic products.

Relative to ethane steam cracking (see May issue) producing ethylene from coal is far more complex and requires the availability of low cost coal to off-set the higher capital and non feedstock operating costs. These two routes are compared in Figure 2 where the sensitivity of ethylene production cost is plotted against the feedstock price expressed in energy terms ($/GJ).





The diagram clearly illustrates the cost advantage of using ethane steam cracking to produce ethylene mainly as a consequence of the lower capital cost (lower intercept on the ordinate axis) and the steeper slope of the line which reflects the lower thermal efficiency of the process - 30% for coal compared to about 77% for ethane cracking.

So why is China pursuing this process, there are several reasons. Gas resources in China are remote and not well developed, in fact China imports LNG into the eastern seaboard so there is little ethane for cracking into chemicals. The principal feedstock is naphtha which is used in large integrated facilities in the east from imported oil or naphtha. Production cost is very high and even with the low oil prices at present ethylene production cost is in excess of $1000/t.

China has vast and well developed coal reserves in the west and it makes sense to use this indigenous feedstock rather than imported oil based feedstock. Furthermore, production costs are very low, similar to Australian production costs, so that feedstock is available about $1/GJ ($20 to $30/t). On the above statistics this gives a production cost below the cost of naphtha cracking.

Furthermore, the main process plant can be produced by the Chinese manufacturing industry at a cost saving of 30 to 40% relative to US cost (compare Australia where manufacturing costs are considered to be 40% above US equivalent costs).

The high added value products (commodity plastics and the like) are relatively easy to transport by rail, barge or road so that it makes sense to establish the coal to chemicals facilities in the coal regions rather than on the eastern seaboard.

Olefins are not the only chemicals being produced from coal in China. The PVC industry is long established where coal is converted into acetylene by electrolytic fusion of coal and limestone to produce calcium carbide. Hydrolysis of the carbide produces acetylene to which is added hydrogen chloride to give vinyl chloride monomer then PVC. The intermediate production of methanol has also spurred interest in the production of acetic acid for acetate derived polymers.

In the past five years 9 facilities have been completed and a further 20 are in the planning or construction phase. Together these will produce over 16 million tonnes of polymers.

The poor efficiency which results in a large carbon dioxide emission for these facilities is not today an issue in China. China has promised to reach peak carbon dioxide emission by 2030 by which time many millions of tonnes of chemicals could be being produced from coal. Ironically, this promise to reach a peak carbon dioxide emission in 2030 is lauded by many in the West concerned with limiting emissions but as this analysis shows China's emissions could increase considerably by the 2030 deadline.

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