PERP Program – Acetylene-Based VCM

New Report Alert

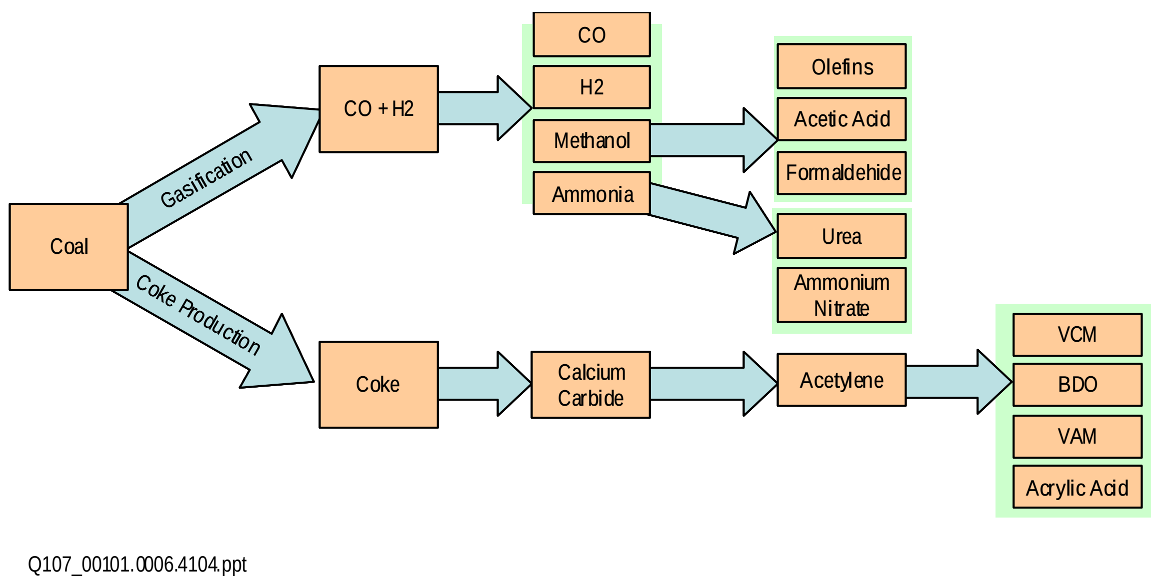
June 2007

Nexant's *ChemSystems* Process Evaluation/Research Planning program has published a new report, ***Acetylene-Based VCM (05/0S4)***. To view the table of contents or order this report, please click on the link below: http://www.chemsystems.com/reports/index.cfm?catID=2

Introduction

Chemicals can be produced from the three principal products of coal gasification; synthesis gas and hydrogen, as well as carbon monoxide. Coal can also serve as a direct feedstock for the production of acetylene via calcium carbide hydration, and, from there, to a wide variety of acetylene-based chemicals. Figure 1 shows routes from coal to chemicals via syngas and via acetylene.

Figure 1 – Coal to Chemicals Options



This report deals with production of vinyl chloride monomer (VCM) from acetylene (derived from coke/coal) in China, as well as from ethylene balanced oxychlorination in the United States.

The oldest and simplest commercial route to vinyl chloride monomer (VCM) is via the vapor phase addition to acetylene (C_2H_2) with anhydrous hydrogen chloride (HCl) over a mercuric chloride ($HgCl_2$) catalyst supported on activated carbon.

The reaction is simple and of high yield when compared to other VCM processes, thereby allowing a simple product purification, no sizeable waste disposal problems, and lower capital and operating costs than the oxychlorination route.

Anhydrous HCl is produced on site via reaction of H_2 and Cl_2.

Acetylene is dried and passed through carbon beds to remove any catalyst poisons (e.g., sulfides).

Anydrous HCl, purified C_2H_2 and recycle (HCl + C_2H_2) are combined, preheated by indirect heat exchange with reactor effluent, and fed to the reactors.

Each reactor is a multi-tube exchanger with heat transfer oil circulated on the shell side to remove the exothermic heat of reaction which in turn generates steam in an external exchanger. Reactor tubes are packed with catalyst pellets which are composed of about 10 wt. percent mercuric chloride ($HgCl_2$) on activated carbon carrier.

As the C_2H_2/HCl feed mixture flows through the catalyst bed, conversion to VCM takes place according to the following reaction:

$$HC{\equiv}CH + HCl \xrightarrow[\text{/Carbon}]{HgCl_2} \underset{\text{VCM}}{CH_2{=}CHCl}$$

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Reactors generally operate at 90 to 140ºC (depending upon catalyst activity) and pressures of 1.5 to 1.6 atm. About 98 to 99 percent conversion of each reactant occurs in each reactor.

The reactor effluent, consisting of VCM, by-products, and unreacted C_2H_2 and HCl, is cooled by indirect heat exchange with reactor feed and scrubbed with H_2O and caustic. Product gas is compressed and cooled, with the condensed VCM and chlorinated hydrocarbon by-products sent to a stripper. Crude VCM from the stripper bottom is purified in a finishing column to remove heavy chlorinated organics and aldehydes for disposal.

Overheads from the VCM stripper go to another absorber-stripper system where acetylene and hydrogen chloride are recycled to the reactor and light chlorinated hydrocarbons are sent to incineration.

Economics

The following VCM cost of production analyses are provided in this report:

- Acetylene-Based in China at 440 MM Lb/Yr
- Speculative ethane-Based in United States at 1,300 MM Lb/Yr
- Ethylene-Based in South Korea at 800 MM Lb/Yr
- Ethylene-Based in United States at 1,300 MM Lb/Yr

The speculative ethane-based oxychlorination shows the lowest cash cost, but high capital investment leads to a second-place ranking on the basis of cost + ROCE. The acetylene-based VCM in China shows the lowest cost + ROCE and the second lowest cash cost. Ethylene-based oxychlorination in South Korea ranks third in terms of both cash cost and cost + ROCE. While the ethylene-based oxychlorination on the U.S. Gulf Coast comes in with the highest ex-plant costs on both cash cost and cost + ROCE bases.

Commercial Analysis

An overview of VCM production facilities is in the following figures. Figure 2 illustrates that China has by far the greatest number of individual facilities – 80 versus 53 for all other countries combined. However, as seen in Figure 3, the average size of VCM plants in China is much smaller than those in other countries. This is particularly so for Chinese VCM plants based on acetylene. Figure 4 shows the breakdown of Chinese VCM capacity by feedstock and also highlights the very rapid capacity growth overall in the last two years. It is interesting to note that the acetylene-based process is maintaining, or even expanding, its proportion of VCM capacity in China.

The majority of VCM (98 percent) is used to produce PVC. The remaining VCM is used to make various copolymers with vinyl stearate, vinyl acetate, vinylidene chloride, and other vinyl ethers, and a declining amount of chlorinated solvents.

The body of the report presents 2006 capacity by producer for the United States, Western Europe, and Asia Pacific as well as supply, demand, and trade balances out to 2010 for the United States, Western Europe, and Asia Pacific.

Figure 2 Number of VCM Plants by Country

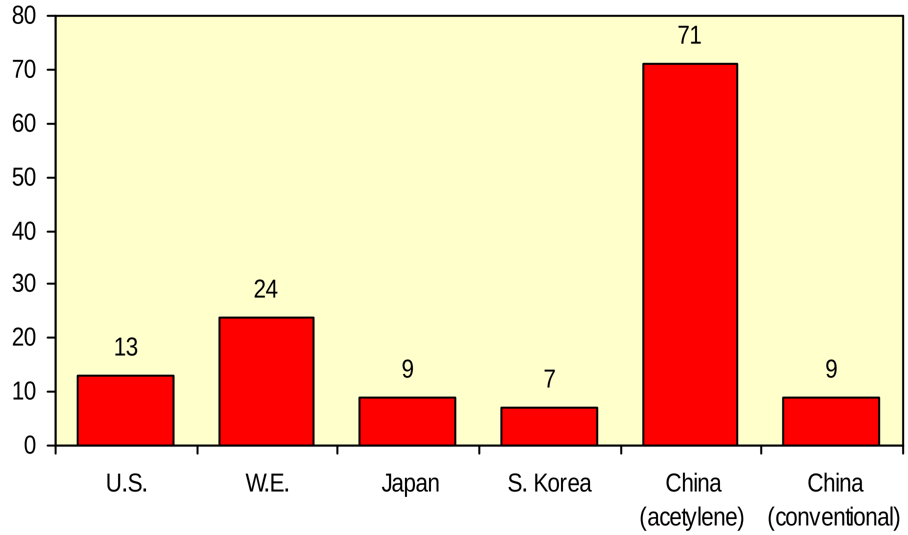

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Figure 3 Average Size of VCM Plants by Country
(Thousand metric tons)

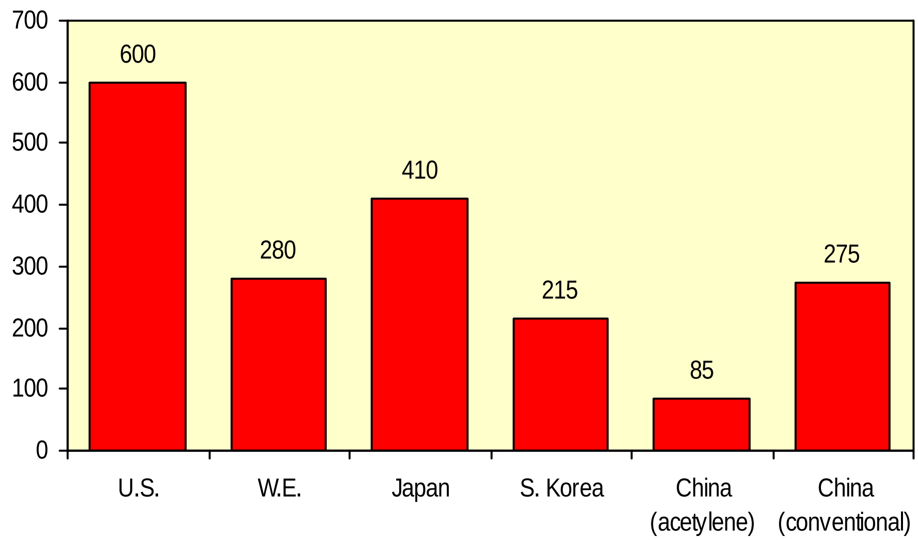

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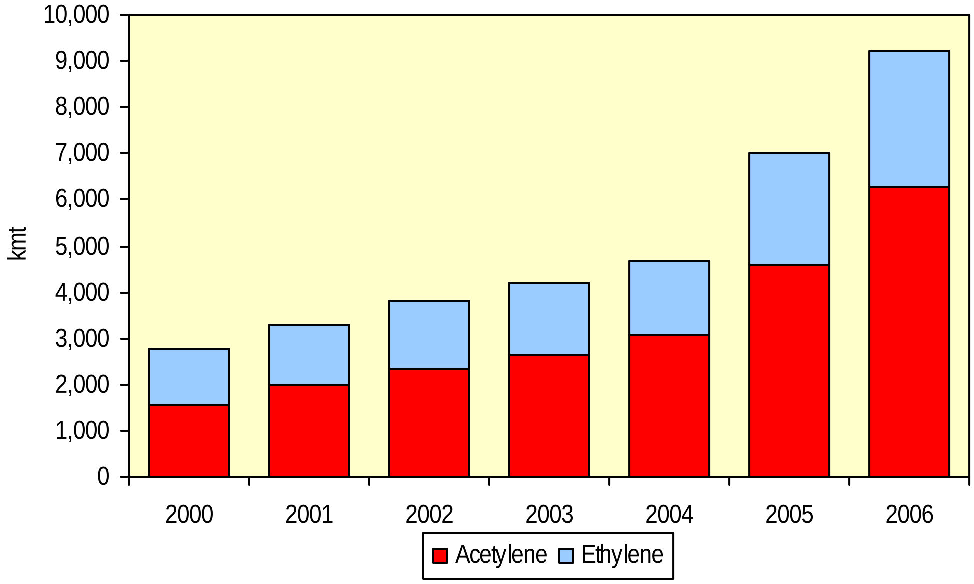
Figure 4 VCM Growth in China by Feedstock



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