Vinyl Chloride from Ethane

(recommended by John Wismer, Atochem North America)

Vinyl chloride is a major commodity chemical. Worldwide consumption exceeds 50 billion lb/yr. The vast majority of vinyl chloride monomer (VCM) is used in the production of PVC (polyvinyl chloride), which has a broad variety of applications. Vinyl chloride is also the main building block for hydrochlorocarbons and hydrofluorocarbons. Worldwide growth trends are very positive.

Your firm (Penn Consultants) has just been awarded a contract from one of the country’s major producers of VCM. The client is an operating company that has sought to become a low-cost producer by running with minimal overheads (no R&D) using a mature technology. This technology is used almost universally to make VCM. The process combines direct chlorination with oxychlorination of ethylene to make ethylene dichloride (EDC – also, dichloroethane).

1) \[ \text{C}_2\text{H}_4 + \text{Cl}_2 \rightarrow \text{C}_2\text{H}_3\text{Cl} \]

2) \[ \text{C}_2\text{H}_4 + \frac{1}{2}\text{O}_2 + 2 \text{HCl} \rightarrow \text{C}_2\text{H}_3\text{Cl} \; + \; \text{H}_2\text{O} \]

EDC is then converted to VCM in a pyrolysis furnace:

3) \[ 2\text{C}_2\text{H}_4\text{Cl}_2 \rightarrow 2\text{C}_2\text{H}_3\text{Cl} \; + \; 2 \text{HCl} \]

HCl from the furnace is recycled to step 2, allowing the process to stay in balance with respect to HCl. A good summary of the technology, with a basic flowsheet, can be found in the *Encyclopedia of Chemical Technology, Fourth Edition* by Kirk and Othmer.

Your client is planning capacity expansions but is concerned about new technologies being developed by competitors that invest heavily in R&D. For the most part, these technologies use ethane, which is cheaper than ethylene, as a feedstock. In fact, ethane is a major feedstock used in the production of ethylene so an ethane-based process eliminates a processing step. Historically, ethane-based processes have had too low a selectivity to be practical. However, there have been some notable recent improvements (see U.S. Patent 5,763,710). Your client’s immediate concern is with a recent patent application filed in Europe by one of their major competitors, Dow Chemical Company (WO0138274 - May, 2001). This is a detailed 85-page application with block diagrams and examples demonstrating how their relatively selective ethane-based process might work. The major breakthrough claimed by Dow is that they can simultaneously convert ethane and ethylene to EDC. This is significant in that ethane-based routes produce a significant amount of ethylene.
non-selectively. Dow claims that they can recycle this to the reactor used to convert the ethane.

Your client has asked your firm to evaluate the potential of this technology by designing a plant and evaluating its capital costs and production requirements. Be optimistic because your client wants to know the best possible scenario. At the same time, you need to identify the significant technical hurdles that Dow might face before commercializing this technology. Assume a plant capacity of 1 billion lb/yr of VCM. Since the ethane technology is a net producer of HCl, the economic analysis must account for the HCl by-product. HCl is a chemical commodity with a volatile price history. However, the current supply/demand balance is favorable to producers and optimistic projections would allow a credit $0.07/lb for by-product HCl. Ethane, ethylene, and chlorine are also commodity chemicals. Price histories may be available from a number of sources including the Bureau of Labor Statistics.

In addition to their concern over Dow building grass roots plants with their technology, your client is concerned about whether Dow can retrofit their existing oxychlorination plants to handle this technology. Without doing a detailed analysis of this mature technology, give a qualitative opinion on retrofitability based on the fundamentals of each process.

References:


U.S. Patent 5,763,710

World Patent 01738274, May 2001