CHAPTER 5

PROCESS TECHNOLOGY/LICENSING ASSESSMENT

This section provides an overview on the state of PTA technology development, background on INCA's technology, comparisons with the other principal technologies currently in use, and outlook for possible further improvements in the technology. In addition, important considerations are highlighted on the critical design and operating know how aspects of the technology.

In general, the basic oxidation and purification technologies for PTA manufacture have been extensively developed. The "experience curve" for the basic process technology is now approaching diminishing returns, and further major breakthroughs (i.e., new catalyst systems, raw materials and basic unit operations) are not anticipated in the future. The leading producers are expected to have greater extent of optimization and energy integration across the entire CTA/PTA complex and more advanced control schemes. Nevertheless, for the same capacity and location, we expect that differences in variable costs for the PTA technologies are relatively small. However, obtaining demonstrated technology and operating know how from an established licensor or operator is absolutely critical for a successful PTA project.

Possible licensing options are highlighted in Table 5.1 and discussed in the following sections.

TABLE 5.1 PTA LICENSING OPTIONS

Amoco	Not available except in equity JVs
ICI	Equity JVs and selective licensing
Mitsui	Equity JVs and selective licensing
Mitsubishi	Equity JVs and selective licensing
INCA	Licensing
Others	Interquisa, Lonza, Huls

5.1 HISTORICAL DEVELOPMENT OF PTA

The principal PTA processes are derived from the basic Mid Century oxidation and Amoco purification processes. Key stages in the historical development of PTA are highlighted below along with the key technical improvements which actually have been implemented commercially. Other improvements studied and patented by the major producers have not been implemented because they are not commercially attractive. Medium purity terephthalic acid (MTA) processes and PTA processes based on hydrolysis of dimethyl terephthalate (DMT) are mentioned briefly in later sections for perspective.

Beginning Stages

Late 1950s	Invention of the basic Mid Century process for cobalt and manganese catalyzed oxidation of para-Xylene

Early Development

(1950s through mid 1960s)	Development and scale up of the basic Mid Century oxidation process (Amoco, ICI, Mitsui); Amoco inven

Development and Dissemination of CTA/PTA Technology

1960s	Development of continuous PTA crystallization process; early improvements in oxidation and purification technology, process control and operating know how
1970s/1980s	Further improvements in oxidation and purification processes; oxidation reactor condensate withdrawal, mother liquor recycle, secondary oxidation, CTA/PTA energy integration, PTA mother liquor solids recovery, milder oxidation conditions for optimization of oxidation reaction; improvements in process control; improvements in PTA optical properties, particulate contamination; improved understanding of relationship between key PTA quality parameters and polyester quality
1970s/1 980s	Efforts by many companies (including Japanese producers and Eastman) to develop medium purity terephthalic acid (MTA) Processes
1960s/1980s	Extensive licensing of PTA processes worldwide by the major producers, Amoco, ICI, Mitsui, and Mitsubishi
1990s+	Major buildup in global polyester fiber and PET resin markets and PTA capacity; increasing competition for market position and competitive advantage; back integration by polyester producers; movement towards larger capacity plants to provide improved economy of scale aimed at supplying captive, local, and regional markets (especially Asia); withdrawal of some major producers from PTA licensing

Key Events in Patents and Licensing

Early 1980s	Expiration of the fundamental oxidation process patents
Late 1980s	Expiration of the fundamental purification process patents
Late 1980s	Entry of Tecnimont (INCA) into field of PTA licensing; first license awarded to Kohap Petrochemical in 1987
1995	Dow acquired 80 percent interest in Montedison's polyester and PTA assets and rights to PTA licensing, under the joint venture INCA
Late 1990s	Interest by others in PTA licensing (e.g., Interquisa, Lonza, Huls)

5.2 CURRENT DEVELOPMENTS AND COMPETITIVE ENVIRONMENT

Given the current state of development of CTA/PTA technology, the major factors affecting competitive advantage relate to economy of scale, site-specific cost factors, logistics costs, regional and local market positions, and operating experience:

- CTA/PTA processes derived from the Mid Century oxidation and Amoco purification process are technically equivalent but may differ in application of specific steps and engineering designs, e.g., equipment details and energy integration

- Recent trend towards larger PTA capacities provide savings in capital investment per unit of annual capacity and cash operating costs. Examples include Amoco's 500 thousand metric ton per year plants at Cooper River, South Carolina and Kuantan, Malaysia and Tuntex's study for a 900 thousand metric ton per year plant at Map Ta Phut (it is not clear if this project will proceed at this time). Larger capacities provide savings in investment and cash operating cost

- Offsites requirements especially infrastructure (land development, marine terminal, desalination unit, etc.)

- Local factor costs including power and labor

- With relatively mature PTA technology, logistics costs can be a major source of competitive cost advantage

- Having long-term offtake commitments is a source of competitive advantage and a requirement for project financing

- Addition of steam and power cogeneration to the CTA/PTA complex. This can provide improved economics for the overall complex depending on local promotion and conditions for Independent Power Plant (IPP) projects

- EPC project execution-licensor's alliance with a limited number of contractors having strong project management capability and familiar with the technology; standardization of engineering design and equipment selection and sourcing; minimization of EPC project cycle based on all of the above factors. Amoco has standardized designs and uses a limited number of EPC contractors (e.g., TPL and Chiyoda) as has ICI (e.g., Foster Wheeler). Japanese companies use affiliated EPC contractors, e.g., Mitsui uses Mitsui Shipbuilding and Mitsubishi Chemical uses Mitsubishi Heavy Industries

5.3 DESIGN AND OPERATING KNOW HOW CONSIDERATIONS

Although the fundamental patents covering the oxidation and purification processes have expired, obtaining the required know how for designing and operating the CTA and, PTA processes is critical. Some of the important areas are highlighted in the following sections.

5.3.1 Materials of Construction

Titanium must be used in critical sections of the CTA process because of the corrosive nature of acetic acid at elevated temperatures.

The refractory walls of the rotary steam tube dryers have historically been a source of maintenance and operating problems. This is no longer a major problem today.

Critical design of powder handling systems is important including pneumatic conveying systems, dryer screw feeders and rotary air valves, CTA and PTA silo systems, etc.

5.3.2 Explosion and Flammability Characteristics

The startup sequence of an oxidation reactor requires the concentration of oxygen together with acetic acid and para-Xylene vapors to unavoidably pass through the explosive envelop for the gaseous mixture. Problems are avoided with proven and experienced operating practices.

5.3.3 Slurry Handling

Pressure vessel discharge valves in slurry service is a critical area particularly in crystallizing conditions. Valves and transfer lines can plug if not designed properly.

5.4 INCA PTA AND RELATED TECHNOLOGIES

The Mid Century liquid-phase catalytic oxidation of para-Xylene to terephthalic acid was invented in the late 1950's by Scientific Design Company and developed by Standard Oil of Indiana (now Amoco Corporation). The unique feature of the oxidation chemistry is the ability of cobalt or mixed cobalt/manganese ligand catalysts to selectively oxidize methyl groups on aromatic rings to the corresponding carboxylic acid groups with minimal "complete oxidation" of the methyl groups to carbon oxides and with minimal oxidative destruction of the aromatic ring structure.

Amoco was awarded a patent in 1965 for a process to purify terephthalic acid which provided the key learning of the hydrogenation of crude terephthalic acid in water solution over Group VIII noble metal catalysts to convert the major impurity, 4carboxybenzaldehyde (4-CBA) to para-toluic acid which is easily removed by recrystallization.

The polyester industry was initially supplied by dimethyl terephthalate (DMT). The availability of low-cost supplies of purified terephthalic acid (PTA) has been the underlying basis for the development of the global poly(ethylene terephthalate) or polyester industry over the past 40 years. PTA's share versus DMT's grew steadily over the years and now stands at more than 85 percent. DMT is still used by some producers with existing plants and captive DMT-based downstream polyester operations, such as Hoechst and DuPont.

In addition, during the 1970s and 1980s, many companies including many Japanese companies, Eastman, and DuPont developed medium purity terephthalic acid (MTA) processes with the aim of providing lower cost product and patent positions outside the claims of the basic existing patents. Mitsubishi, Eastman, and DuPont commercialized their processes.

ATC' management assessment of INCA's PTA technology and other technologies is provided below.

5.4.1 INCA's PTA Technology

INCA's PTA technology was originally licensed in the late 1960s from Amoco by Montedipe, the petrochemical division of the Montedison Group. Montedipe constructed a 60 thousand metric ton per year PTA plant at its petrochemical complex in Porto Marghera (Venice, Italy). The process was based on Amoco's current PTA technology at that time, and the licensing terms did not provide any subsequent Amoco improvements developed. The following information was highlighted in the information provided to ATC by INCA, and ATC' management opinions are noted in italics.

- Montidipe plant and research personnel studied and implemented a number of process improvements over the original process after the Amoco license had expired. Some of the improvements were patented. *ATC believes that the improvements implemented by Tecnimont were consistent with developments in the industry during that period of time.*

- Oxidation reactor "water withdrawal"--a substantial portion of water produced by the oxidation reaction was withdrawn from the oxidation reaction off-gas condensate prior to returning the condensate to the reactor. This provides improved para-xylene conversion efficiency by reducing reactor water content. *This important improvement was implemented by most* major *producers in the 1970s and early 1980s.*

- Mother liquor recycle--more than 50 percent of the mother liquor (containing liquid catalyst solution) from crude terephthalic acid filtration was recycled back to the oxidation reactor feed solvent makeup reducing catalyst consumption by about 50 percent. *This also was an important improvement implemented by most producers in the 1970s and early 1980s.*

- Azeotropic distillation of acetic acid reducing reboiler heating requirements by approximately 50 percent. Mitsui developed azeotropic distillation for purification of acetic acid solvent in the early stage of development of its process which was utilized at its plants at Iwakuni, Honshu. *The decision to use conventional binary (thermal) distillation* or *azeotropic distillation is based on optimization of capital and operating costs.*

- PTA crystallization--crystallization was transformed from batch to continuous operation which improved productivity. Amoco developed and was awarded a US patent for its continuous PTA crystallization process in the late 1960s. *This technology was not part of the license acquired by Montedison and the license did not require providing it to Montedison at a later time.*

Tecnimont took part in the engineering and construction of the Montedison PTA plant at Porto Marghera and at a later plant constructed by Montedison/Enichem which started up in 1984. Following the expiration of secrecy agreements with Amoco in 1984, Tecnimont obtained from Montedison the right to promote and commercialize Montedison's PTA technology which is now owned by INCA. Tecnimont developed a process engineering package which included the technology improvements developed at the Porto Marghera plant and incorporated innovative improvements and approaches to general engineering, materials, and energy savings, including:

- Improved oxidation reactor gas-solid-liquid contacting/mixing

- Low water content in the oxidation reaction mixture by removal of conden (water withdrawal)

- High purity of PTA product and lower by-product formation as a consequence of using milder reactor conditions

- Reduced energy consumption as a result of use of high pressure reactor off-gas and surplus process steam (with preheat from PTA crystallizers flash steam) to drive first stage turbine of the process compressor

- Reduced maintenance costs as a result of milder operating conditions

ATC believes that improvements made by Montedison and Tecnimont followed and were consistent with improvements and practices of the major producers at the time.

Tecnimont obtained its first contract in 1987 to license its PTA technology to Kohap at Ulsan, South Korea which Kohap subsequently debottlenecked. Its second license was to Tuntex (Taiwan) which was also later debottlenecked. The terms of this licensing agreement provided Tuntex the right to use the technology in a second plant, i.e., Tuntex's PTA plant at Map Ta Phut.

5.4.2 Amoco PTA Technology

PTA is Amoco's most important core petrochemical business. During the 1960s through 1980s Amoco licensed extensively; ATC estimates that Amoco's licenses worldwide (expired and active) numbers more than 50. Due to it is apparent from Chem Systems various work over time on PTA technology and patent reviews that Amoco has committed extensive research and development efforts to develop and implement fundamental improvements to the basic CTA/PTA technology. ATC believes that Amoco has implemented most of all the important process/chemistry improvements highlighted in previous sections as well as substantial engineering improvements, e.g., related to energy integration.

Amoco has worked on numerous improvements involving optimization/ integration of the CTA and PTA processes. Patents have been issued to Amoco for a process involving separation of crude terephthalic acid from acetic acid oxidation solvent; reslurrying in fresh acetic acid; and transferring directly to the hydrogenation purification step. This process would provide energy and capital savings by avoiding crude terephthalic acid drying and intermediate storage. Other Amoco patents have discussed using an oxidation catalyst system with no cobalt, none of these features are used commercially. ATC does not believe that these improvements have been implemented commercially. Some other improvements which are not big "step outs," such as improvements in the hydrogenation catalyst, may be in use commercially.

5.4.3 ICI PTA Technology

ICI's interest in polyester is of significant historical importance. ICI held the initial composition of matter patents for producing polyester ("Winfield patents") dating back to the late 1940s. ICI obtained the rights to use the Mid Century oxidation process and original process and engineering package from Scientific Design Company. The process was initially used to produce CTA intermediate for DMT production. ICI obtained a PTA license from Amoco in the early 1970s. ICI has also committed substantial research and development efforts to improving its CTA/PTA technology. ICI's process is considered to be technically equivalent to Amoco's. Since the expiration of its license with Amoco, ICI licensed its PTA technology, but now doing so only selectively. 101 is now constructing a wholly owned PTA plant at Port Qasim, Pakistan and has formed a joint venture in Taiwan with FETL. ICI licensed to Polyprima (1997 startup) without holding an equity position.

ICI's PTA is known to contain lower levels of 4-CBA which would result from lower production of 4-CBA at more severe conditions in the oxidation process, more conversion at more severe hydrogenation conditions in the PTA process, more thorough purification during PTA recrystallization and recovery, or a combination thereof.

ICI has developed approaches to integrating the CTA and PTA process involving replacement of the residual acetic acid in crude terephthalic acid filter cake with makeup water before transferring to the hydrogenation step and improved CTA/PTA complex energy efficiency. ICI claims that this technology will be applied in a future plant.

5.4.4 Mitsui PTA Technology

Mitsui Petrochemical (now Mitsui Seka) acquired the rights to use the basic Mid Century oxidation process from the Scientific Design Company and obtained a process and engineering design package for its first plant at Iwakuni. Mitsui's CTA process is geared towards relatively mild oxidation conditions and uses azeotropic distillation for purification of acetic acid solvent. Mitsui initially produced DMT by esterification of CTA and obtained the rights to Amoco's PTA process in the mid 1970s. Mitsui's CTA/PTA technology is considered technically equivalent to Amoco's and ICI's. Mitsui licenses primarily to its own joint ventures but selectively to others (e.g., projects in China).

5.4.5 Mitsubishi QTA AND PTA Technologies

Mitsubishi Chemical initially produced PTA (jointly with Toray) by the "Henkel" process, but shifted their focus in the late 1970s to develop a medium purity terephthalic acid, which they designated QTA. Mitsubishi later added an Amoco style PTA plant in order to provide product having higher quality needed for critical fiber, container, and film applications. It is believed that Mitsubishi patterned their PTA process after the Maruzen Oil PTA plant which was one of Amoco's earliest PTA licenses. Mitsubishi QTA is produced using an extended acetic acid wash and "digestion" or "heat soak" of crude terephthalic acid crystallizer effluent slurry. A cause of some concern, Mitsubishi has had at least two fires (from causes unknown) during the past several years at its plants in Japan. ATC is not aware of any similar problems at Mitsubishi licensee plants, e.g., Sam Nam in Korea, and Bakrie Kasei I and II at Merak. Mitsubishi licenses primary to its own joint ventures.

5.4.6 Tuntex PTA Technology

Tuntex (Taiwan) licensed its PTA technology from Tecnimont in 1988 which provided the rights to use the technology in a second plant which was later constructed at Map Ta Phut. Tuntex has expanded the capacity of its Tainan plant from its original capacity of 285 thousand metric tons per year to 420 thousand metric tons per year. The capacity of the Map Ta Phut plant (1995 startup) was expanded from 350 thousand metric tons per year to 420 thousand metric tons per year. Tuntex's technology is considered technically equivalent to that which INCA has proposed to ATC in its licensing package.

5.4.7 Interquisa PTA Technology

Interquisa was originally a joint venture between Amoco and Cepsa, one of the largest private companies in Spain. The joint venture constructed an Amoco based PTA plant and Eastman based DMT plant at San Roque, Cadiz, Spain in the 1970s. Amoco was forced to sell out its shares in the late 1980s as a result of conflict of interest with Cepsa in connection with plans to expand the facility to supply the European polyester market. Interquisa recently was mentioned as a possible licensor to Indorama in India who are now developing a PTA project (Mitsui has also been mentioned as a possible partner/technology supplier). Interquisa has not licensed PTA technology previously.

For this research, ATC called Interquisa at San Roque to inquire on a confidential basis whether Interquisa would be interested in principle in licensing their technology to a Southeast Asian company. Interquisa would be interested in developing this further but said that they would need to understand the party involved and whether this would conflict with Interquisa's direct marketing strategy. Once Interquisa understands these points, ATC could hold further discussions with Interquisa. The Interquisa contact indicated that they have made improvements to the initial Amoco license.

5.4.8 Eastman MTA Technology

Eastman focuses on producing terephthalate intermediates for its polyester applications. Eastman historically produced DMT and developed MTA during the 1980s. Eastman's MTA process initially used acetaldehyde as promoter similar to Sisas' MTA process but Eastman later switched to use of more efficient bromine promoter. Eastman has recently licensed a commercial PTA process to Sunkyong and Polysindo (1997 start up) and is interested in licensing in Asia.

5.4.9 Lonza PTA Technology

Lonza is constructing a purified isophthalic acid (PIA) plant on Pulau Sakra, Singapore in a joint venture with the Economic Development Board (Lonza share 80 percent). ATC asked Lonza whether they were offering PTA technology for license. The major components of Lonza's PTA technology is expected to be very similar to their PIA technology which is demonstrated in wholly owned facilities in Switzerland. Lonza stated that they are offering their PTA technology in cooperation with a major engineering firm. This PTA process has not been licensed. The production of PIA involves the same basic steps as producing PTA; however, because of the different reaction and solubility characteristics of PIA versus PTA, process conditions and know how for some of the steps are somewhat different. On this basis (and without having examined a licensing package) ATC considers the Lonza PTA process to be unproven.

5.4.10 Huls/"Witten" DMT and PTA

The "Witten" process for DMT was developed in the 1950s and used by a number of companies including Dynamit, Huls, Hoechst, and Hercules. The process involves successive stages of oxidation and esterification of para-Xylene with recycle of partly converted intermediates to complete the oxidation and esterification process to produce the final product DMT. The combined process involves less severe catalyst and operating conditions with savings in materials of construction. DMT's disadvantage versus PTA is production of byproduct methanol which must be disposed of. The process is still in use today by companies which are integrated to polyester including Hoechst and Teijin.

Hercules developed a process to hydrolyze DMT in water to produce PTA and commercialized in a facility at Wilmington, South Carolina.- Hoechst operates this plant today. The combined DMT/hydrolysis PTA process is-not economical but produces the best Product quality in the industry.

In addition, Dynamit Nobel, Huls, and Hercules develop processes in the 1970s to produce PTA using a modified Witten DMT process. The process claimed to co-produce DMT and PTA. Dynamit licensed a version of this process to Formosa Chemicals and Fibers Company or FCFC (Nan Ya, Taiwan); however, FCFC has had difficulty operating the facility up to expectations.

Huls has recently been promoting their technology which is expected to be similar to Dynamit Nobel's.

5.4.11 Others

Glitsch has been heavily promoting its developments in the area of DMT/PTA. It announced that it developed "breakthrough" technology for DMT and PTA which will provide substantial increases in capacity and reductions in operating costs. Glitsch has licensed improved systems to improve vapor/liquid contacting in conventional distillation processes, but ATC does not consider this to be breakthrough technology applied to the basic PTA and DMT processes. Such improvements would allow debottlenecking of existing plants and reduce the capital investment in new plants, and have been applied in Bombay Dyeing's DMT plant and Interquisa's San Roque PTA plant. ATC consideration of Glitsch's technology as an option in the basic engineering design for the PTA project.

Praxair/Lummus have been promoting improved oxygen contacting devices using pure oxygen in place of compressed air to improve the efficiency of the para-Xylene oxidation reaction. This is considered to be an incremental improvement and has not been demonstrated on a commercial scale for para-Xylene oxidation.

5.5 PRODUCT QUALITY CONSIDERATIONS

The following provides an overview of key considerations related to product quality.

- Organic impurities include aromatic byproducts and trace acetic acid. The major aromatic impurities are 4-CBA and para-toluic acid. Trace aromatic impurities are primarily responsible for color formation in the PTA product

- Absolute quality levels in PTA (e.g., 4-CBA) among the principal technologies are generally acceptable for polyester fiber and PET resin. Among the major producers, ICI's 4-CBA levels are lowest, on the order of 5 ppm, and Tuntex's are among the highest, on the order of 25 ppm

- Variability in quality (e.g., 4-CBA) is critically important and derives from controllability of the CTA and PTA processes. "Tuning" the polycondensation process to higher absolute levels of 4-CBA is possible so long as the variability is low. In this manner some polyester producers use blends of QTA and PTA

- Optical properties or color of PTA results primarily from multi-ring compounds which are side products in the oxidation reaction. 100 percent pure PTA is colorless. Color promoting characteristics of some of the impurities are modified in the hydrogenation process, requiring control across both the CTA and PTA processes

- Particulate contamination, (referred to as "black specks" in the industry, is important in some polyester fiber, PET resin, and is critically important in polyester thin-film applications. Many PTA producers have specifications on the number of particles greater than 10 microns in diameter; however, some thin-film applications, e.g., microcapacitors for printed circuit boards, require film thicknesses of 1 to 2 microns. Fine particles derive mainly from the Pd/C hydrogenation catalyst and scrap metals from the process equipment. For these critical applications some producers still prefer to use DMT

- QTA is used in fiber and PET resin production in blends with PTA to provide suitable product quality. This is possible by controlling the variability in quality of the blended feed to polycondensation

- Because the INCA CTA/PTA process is basically similar to those of the other major producers, ATC expects the INCA product quality to be comparable

5.6 RECENT TECHNICAL DEVELOPMENTS IN PTA TECHNOLOGY

Amoco and ICI have been the most active in the area of PTA processing improvements. The primary focus has been to try to develop processes which integrate the oxidation and purification processes and to implement enhanced energy recovery and energy integration improvements. Recent topics in the patents awarded to these companies include:

- Energy efficient aromatic carboxylic acid preparation process (patent WO 9611899 issued to Amoco)

- Crude terephthalic acid produced using a titanium dioxide-supported catalyst (patent WO 9420447 issued to Amoco)

- Reduced residual solvent in crude aromatic polycarboxylic acid by washing with water using countercurrent positive displacement process (US patent 5,200,557 issued to Amoco)

- Transfer of crystallization solids from the high to low pressure zones using a pressure isolating device independently heated to compensate for temperature differentials produced within the device (WO 9519335 issued to ICI)

- Recovery of terephthalic acid crystals using a two-step filtration at different temperatures and pressures with reslurrying and flashing of the solvent between steps giving improved water conservation (WO 9419082 issued to ICI)

- An improved wash which allows re-optimization of the oxidation such that higher impurity levels can be tolerated (European Patent 722927 issued to ICI)

- Use of hafnium as a tertiary oxidation catalyst component aimed at reducing consumption of the more expensive cobalt catalyst (US patent 5,112,992 issued to Amoco)

- Oxidation reaction control by separate control of acetate ion concentration (US patent 5,081,290 issued to Amoco)

- Improved washing and purification procedures (E.P. patent 502 628 issued to ICI)

- Catalyst reactivation (US patent 4,808,751 issued to Amoco)

- Acetic acid recovery (US patent 5,113,015 issued to Amoco)

- Numerous patents for the recovery and purification of PTA from waste polyester film, fibers, bottles, etc.

- Other companies have received miscellaneous patents in the PTA or DMT area including Mitsubishi Chemical, DuPont, Eastman, Hoechst, and Glitsch.

5.7 CRITICAL ASSESSMENT OF PTA LICENSOR

A critical assessment of PTA competitive licensor is provided below for major cost elements including para-Xylene and acetic acid. para-Xylene and acetic acid consumptions depend primarily on:

- Severity of the oxidation reaction and "burning" losses
- Recovery and recycle of byproducts in liquid and vent gas streams
- PTA mother liquor solids recovery with PTA recovery and recycle of para-toluic acid to the oxidation step
- Operability of the combined CTA and PTA units and minimization of interruptions

INCA's para-xylene consumption is considered competitive with the industry while its acetic acid consumption is considered to be higher than average but it is not significant due to PTA process consume Acetic Acid at very low volume and the price of Acetic Acid is not high to impact the production cost of PTA. Moreover, INCA is the only one licenser that sell their technology without any obligation such as joint venture or not for sell. The critical assessment of PTA competitive licensor are summarized in Table 5.2.

TABLE 5.2
CRITICAL ASSESSMENT OF PTA COMPETITIVE LICENSOR

	para-Xylene	Acetic Acid
Unit cost, US$/ton	550	600
Consumption, ton per ton PTA		
INCA	0.665	0.06
Others	0.66-0.68	0.05-0.065
Variable cash cost, US$ per ton PTA		
INCA	366	36
Others	363-374	30-39
PTA Licensing Option		
INCA	Licensing	
Others	Not available or selective licensing	

INCA's basic CTA/PTA processes are technically similar to those of the other major producers. Therefore, ATC believes that the variable cash cost of production could be comparable with those of the others given the same basic design and operating practices. Moreover, from technical, cost of production and licensing, ATC believe in INCA's PTA is the most suitable to select from several competitive technologies.