PART 3 – AROMA CHEMICALS from PETROCHEMICAL FEEDSTOCKS

14 KEY SUCCESS FACTORS

The characteristics, dynamics and key success factors for the different sectors of the chemical industry namely commodity, fine and specialty chemicals differ widely. This is demonstrated below in Table 42. Speciality and Fine chemicals are defined as follows:

- Fine Chemicals are pure, single substances sold on the basis of their chemical identity to an agreed chemical specification. They are differentiated from commodity chemicals by price, and generally sell for $5/kg or higher.
- Speciality Chemicals are sold to performance specifications for what they do i.e. they are bought and sold for their effect. They are rarely identified by chemical composition. They could be single compounds or mixtures of substances formulated with carriers or solvents. They almost always require formulating know-how, even when the products sold are complex synthesised molecules. Very often, the exact chemical compositions are trade secrets, and there can be many possible formulations for the same purpose. They are sometimes therefore referred to as “effect” or “functional” chemicals.

Table 42: Organic Chemical Industry Characteristics[48]

	Commodity Chemicals	**Fine Chemicals**	**Speciality Chemicals**
Industry Characteristics Product Differentiation	None	Low	High
Product Prices	< $ 5/kg	>$5/kg	>$10/kg
Value Added	Low	High	High
R&D Focus	Process Improvement	Process Development	Application/ Product
Capital intensity	High	Moderate	Moderate/Low
Key Industry Success Factors Low Cost Position (Importance)	High	Moderate	Low
Technical Service/ Application know-how (Importance)	Low	Moderate	High
Close links with the customer (Importance)	Low	High	High
Petrochemicals Aroma and Fine Chemical Value Chain	**Bulk Intermediates** pHB, pAA, tech. grade thymol	**Aroma Chemicals** OMC, Menthol, flavour grade pAA	

48 The Fine Chemicals Industry – the exodus outside the Triad? E Polastro, J Nylstrom (A.D. Little)

As one moves up the value chain therefore, the main key success factors for fine and speciality chemicals are more related to know-how, the provision of technical services and close customer relationships rather than just low delivered prices. Reliable, consistent product quality and the ability to meet an approved organoleptic profile in the case of aroma chemicals become of paramount importance.

The portfolio of petrochemical aroma chemicals, menthol, OMC, ethyl vanillin and vanillin have the characteristics of fine chemicals, whereas technical grade pHB, technical grade pAA and thymol, the bulk intermediate inputs, resemble bulk commodity chemicals in nature.

Due to the concentration in the fine chemicals industry which started a few years ago, current new regulatory and competitive elements have introduced a new element, the need and scope for economies of scale and overall efficiencies. These new key success factors are associated with the:

- More stringent environmental and operating requirements requiring a sizeable investment in non-directly productive assets e.g. quality control and environmental compliance. This imposes a minimal critical mass to spread the fixed costs associated with these.
- Generally more competitive and volatile market environments. Companies therefore need to rely on a broader portfolio of products in order to avoid an excessive dependence on a single product and/or customer group.
- Changing customer requirements. Customers now tend to look for suppliers that can provide complete service capabilities.
- Emergence of new competitors particularly outside of the traditional fine chemicals countries such as Europe and the USA. These competitors often have substantial cost advantages. The emergence of these players has resulted in overcapacity in many markets, resulting in collapsing prices and the exit of marginal players.

Clusters of companies with broad technology and product portfolios have emerged. This is a significant change compared to the past where companies in the industry tended to compete mainly in selected niches and with limited sales. Critical mass is generally estimated to be in the region of $ 50 million.[49]

It is within this general context that this study has identified a number of specific key success factors relevant to a potential new entrant/investor in the proposed Petrochemical Aroma and Fine Chemical business.

[49] Towards High Performance in the Fine Chemicals Industry: E Polastro

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PART 3 – AROMA CHEMICALS from PETROCHEMICAL FEEDSTOCKS

14.1 World-Scale Businesses

The minimum economic size for stand-alone plants have been determined, and for the pHB and pAA plants this was considered to be 2,000 tons. However, as the production of neither of these intermediates is proposed as pure stand-alone businesses marketing the intermediates internationally, their inclusion into a portfolio of aroma chemicals allows some flexibility with respect to capacity. Capacities for pHB and pAA of 1 690 tpa and 1 720 tpa respectively have been determined through a techno-economic analysis of the optimised basket of products. These capacities are within the range of the economy of scale.

The optimised product portfolio as defined above is $ 40 million. This business is large enough to offer a viable product and technology portfolio and to present a credible partner to end user industries. The competitive advantage presented by the CSIR technology will offer a unique technological capability, allowing the combination of a number of aroma chemicals to be produced, thereby giving a business of critical mass.

14.2 Implementing leading edge technology

Within the context of the petrochemical portfolio of aroma chemicals, although menthol, OMC, ethyl vanillin and vanillin have the characteristic of fine chemicals, these specific products are mature products in the late stage of their product life cycles. These products therefore compete mainly on price. Reliable, consistent product quality is assumed as a given by the market. Verification of this however forms part of the extensive product qualification process. Thus, a critical success factor for sustainability and competitiveness of the value chain is that the producer of the aroma chemicals part of the chain has a cost position comparable with the lowest cost producer of these specific products.

The pHB/pAA and Mbuyu Menthol technologies *per se* are mobile, and there is nothing inherent in the processes making them distinctively South African. The technologies could in fact be implemented anywhere in the world using any of the commercially available mixed cresol products. The evaluation of the technology packages (both benchmarking and investment analyses) were performed on the basis of using any commercial mixed cresol feedstock provided it meets the technology requirements. The evaluation of the technologies however has been done within the framework of the value chain proposed in this study on the naturally arising m-cresol.

In the case of this value chain and product portfolio, the technology-driven competitiveness of the CSIR technologies for pHB and pAA production has been demonstrated by benchmarking exercises against the international market leaders. The methodology used was to benchmark the processes on an international basis (in US $) in order to determine the technologies inherent competitiveness. This approach was adopted particularly to ensure that the processes would not be dependant on any exchange rate advantages, which may or may not be sustainable.

The competitiveness of a South African pAA producer employing the pHB-pAA technology developed by the CSIR was benchmarked against the world's leading producer, Atul. The analysis demonstrated that the producer would be able to compete and retain its competitive position should it source MP96 at a purchase price of $ 1.40/kg and sell the naturally arising by-product m-cresol at prices greater than $1.80/kg.

It has been discussed earlier that in order to compete in the pAA merchant market, a producer must sell a substantial quantity of product to an OMC producer. The benchmarking analysis determined that a South African OMC producer with a captive source of pAA from a dedicated pAA plant will be able to compete on a cash cost basis with the market leader, BASF, provided that it can purchase the mixed cresol at a price of $1,250–1,560/ton (100% cresol) and that it can sell m-cresol at prices greater than $ 1,800/ton. The OMC competitiveness can be achieved with existing commercial OMC technology. South Africa does not as yet have access to an internationally competitive OMC technology, the technology would have to be licensed internationally to kick start the production of aroma chemicals in this value chain.

The novel menthol technology developed by the CSIR is inherently a competitive process compared to existing commercial process routes. This is related to the key biotransformation step of the menthol isomers. At the m-cresol sales prices required in order for the pHB-pAA-OMC process to be competitive, the menthol technology process has a substantial advantage over the current synthetic cost leader, Symrise. The use of the naturally arising m-cresol from the pHB-pAA-OMC process therefore could be used to produce menthol in an optimised facility for the production of these products without rendering either of the processes uncompetitive.

Investment economics for these products would be achieved under the scenario outlined in the techno-economic evaluation.

14.3 Implementing Leading Edge Operations

14.3.1 Location: World-class services and infrastructure

The assessment of the technology packages was performed on the basis of an Inside Battery Limit capital estimate, and the provision of utilities and services being supplied over the "fence". The prices for the utilities at which the producer would be competitive have been defined and the major utility requirements for the complex envisaged quantified for the purposes of a techno-economic evaluation. The requirements were significant, and could potentially justify a stand-alone utility facility although there is insufficient process detail to fully specify the utilities facility.

1. The facility is a relatively high specific steam consumer (~140 000 tpa). Each of the individual plants raising or purchasing (depending on different site locations in South Africa) its own steam would detract from the beneficial economy of scale.
2. Refrigeration capacity, potable water supply, air supply, and cooling water supply for the plants purchasing large quantities of power from an electricity supplier (15,5 MWh) would benefit from scale of operation.
3. Various liquid and solid effluents requiring process treatment prior to disposal could be centralised.
4. By centralising utilities and services, the manning structures could be simplified thus reducing the manning cost.

Combining utilities and services into a separate entity could allow such an entity to benefit from economy of scale and allow it to be recognised as a much lower risk business that could apply lower investment hurdle rates to its operation. Such a site would therefore, through the utilities and services business entity, provide the service, effluent and utility cost synergies. The project as proposed would provide the basis upon which this can be realized.

This site should also have the potential for expansion. The site must in addition maintain the highest environmental and safety standards. This will give South Africa an advantage over many countries where the adherence to safety and environmental regulations is often sub-standard. Customers routinely inspect the facilities of potential suppliers to assess not only their adherence to good manufacturing procedures and quality-control practices, but also their environmental and safety practices and standards.

South Africa subscribes to the major international environmental conventions, including the Basel Convention on the Trans-boundary Movement of Hazardous Wastes. Recently the government has introduced regulations aimed at promoting cooperative environmental management and providing guidelines for the disposal of hazardous waste. The chemical sector in South Africa subscribes to good environmental, health and safety practices. Safety standards are rigorously enforced, and most producers are participants in the Chemical and Allied Industry Association's Responsible Care Programme. It is considered that South Africa's position with respect to Environmental Compliance internationally will not be a critical constraint in the establishment of this value chain.

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There could be a number of such potential sites within South Africa, which could provide the basis for this world-class utilities and services entity.

14.3.2 Labour and Staffing

The ability of a country to supply properly trained staff is critical to the success with which the plants will operate. Most plants in the USA and Western Europe are efficiently designed, built, operated and maintained and therefore operate at optimum efficiency. The supply of skilled scientists and engineers at all levels is therefore a critical success factor. For both Bulk Intermediates and the Aroma and Fine Chemicals, in order to stay competitive into the future, it is essential that the producer maintain its cost leadership position. The producer should therefore have an ability to implement continuous improvement manufacturing processes as well as to develop and apply process enhancements.

This study has determined that the occupational distribution and skills requirements of the Petrochemical Aroma and Fine Chemical value chain mirrors those of the overall chemical industry sector. Typical skills required include: batch processing, small plant operation, product formulation, industrial chemical synthesis etc. It has however been stated in section 1.1 that the South African fine chemical industry and the downstream chemical processing industry is relatively underdeveloped. South Africa has a shortage of suitably trained personnel capable of developing and implementing competitive fine chemical technologies and operating fine chemicals batch process plants.

14.4 Accessing Secure and Competitively Priced Raw Materials

A South African pAA producer using the CSIR developed technology would have the flexibility of starting with a feedstock of varying compositions of p-cresol and m-cresol, ranging from pure p-cresol to a mixture consisting of 40% p-cresol and 60% m-cresol, such as MP99 supplied by Mitsui or Sumika-Merichem. Despite this raw material flexibility, from a reaction chemistry perspective, the ideal composition is a mixture consisting of 50% p-cresol and 50% m-cresol, as would be the case with Merisol's MP99 and MP96 cresol products.

The benchmarking and techno-economic evaluation exercises have indicated the purchase price for MP96 at which the project will have investment economics and at which the producer can supply the products at internationally competitive prices. A mixed cresol feedstock price, equivalent to a pure (100%) cresol price of no more than $ 1,250 – 1,458/ton, is required for the project to be potentially viable.

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14.5 Producing product of consistent quality and quantity

The market is characterised by the fact that flavours and fragrance formulations depend on consistency of supply, both as to quantity and quality. Most end users have a precisely defined specification for their ingredients and it is not unusual for a formulation for a product to have been developed around a particular specification or organoleptic quality acquired from a certain source of the ingredients.

High product quality and reliability of supply would depend on reliable processes and equipment and the application of high manufacturing standards. This again emphasizes the need for adequately trained staff.

The ability to meet the organoleptic requirements of the customer depends on the skills of a "flavour" chemist or olfactory expert. The job requires very specialised technical knowledge. A Chieta Report[50] reports that it is practically impossible to recruit flavourists in South Africa. People with this specialisation gain their skills over many years, very often overseas. South African based multinational Flavour and Fragrance houses often recruit these skills from their overseas counterparts on contract. The critical shortage of skills in this particular area is primarily related to the stage of development of the industry.

It has been reported by the Chieta Skills Needs study that there is an inadequate focus by academic institutions on speciality, functional and bulk formulated manufacturing. Research education in the areas of application-based and formulation-based chemistry is almost non-existent. The academic institutions tend to focus more on technical and theoretical concerns, while commercial issues, especially those related to the identification of commercial process opportunities, are neglected. This presents another critical gap in South Africa's capability of meeting this industry requirement.

14.6 Securing Market Access

The aroma chemical and essential oils industries are characterised by the difficulty of penetrating the international market. Once a product is formulated around a particular supply of aroma chemical, it is very difficult if not impossible for the end-user to change its source of supply. Most aroma chemical purchasers will not change to a new source of supply for a temporary price advantage.

In order to secure reliable markets, there is a long process of "courtship" that must be engaged in. This involves the presentation of samples, the making of adjustments to product or organoleptic quality and the giving of assurances of stable supply. The approval process

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50 Skills Needs In The Chemical Industries Sector In South Africa Research conducted for the Chemical Industries Sector Education and Training Authority and the Department of Trade and Industry.

involves the supply of pilot plant produced samples first for the initial approval, and then actual samples of production lots for final approval. Whilst this barrier to entry is high, once relationships have been developed with international purchasers, stability of off-take is assured, provided that the specifications continue to be met.

As the size of the regional market for all of the products considered is negligible, the majority of the plant's capacity must be exported in order to achieve maximum plant loading. An international marketing position is therefore essential.

The two major drivers in the proposed product portfolio are menthol and pAA. The major market for pAA is OMC, and it has therefore been proposed that the forward integration of the production of OMC from pAA is considered. Hence, a strategy of obtaining market access and securing these long-term relationships for both menthol and OMC must be formulated.

Menthol

A new synthetic producer should not repeat Haarmann and Reimer's[51] mistake in entering the market without committed supply contracts. In 1978 when Haarmann and Reimer opened its second synthetic menthol plant, a 1,100 ton plant in the USA, international plantings of *Mentha Arvensis,* the source of natural menthol, also increased simultaneously. This over-supply lead to depressed prices from 1980 – 1984 and Haarmann and Reimer filed an anti-dumping action against Japan and China. Although the US International Trade Commission ruled that the Chinese had dumped menthol into the US market by selling at less than production costs, Haarmann and Reimer, which was a subsidiary of Bayer AG in Germany at the time, had not suffered a significant financial loss.[52]

Hence the major buyers could be sought out, and long-term supply contracts entered into initially before any funds are committed to a new facility. The best strategy would be to seek an existing synthetic producer in an attempt to persuade them to co-invest in a new plant in South Africa using the Mbuyu Biotech technology.

Octylmethoxycinnamate

The competitive analysis of world pAA/OMC production carried out has shown that no current pAA-based OMC producer can compete with BASF. The analysis furthermore also shows that pAA prices would have to be reduced to below the cash cost of production of Atul in India, the lowest-cost producer, for the OMC producers to have a cash cost lower than that of BASF. This analysis can therefore

[51] Now Symrise
[52] G Clark: Perfumer and Flavourist: Vol 23. Sept/Oct 1998

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also conclude that the only way existing OMC producers are going to effectively compete with BASF is:

- For the OMC producer to own the whole value chain from p-cresol through to OMC *via* PAA, or to be intimately involved in it, or
- For the OMC producer to locate its production facility in a country with a competitive cost base, since the cost base of 1st world countries preclude acceptable economics from being achieved.

For these reasons, existing OMC producers could consider producing OMC in China or together with Atul in India. However, these countries very often are viewed as having 3rd world production capability. South Africa, though, represents a significant opportunity. In particular, it has been demonstrated that use of a competitive OMC technology, coupled with the CSIR pHB/PAA technology will have definite advantages for existing producers in terms of its cost of production and its competitive position opposite BASF. By transferring production to South Africa, the pAA-based OMC producer would become competitive with BASF, but would also give it a lower cash cost of production, ensuring a long-term survival in the OMC market.

It is therefore proposed, that an alliance or strategic partnership with an existing pAA based OMC producer be explored. This partnership would secure market access for the South African pAA producer and in addition, an alliance would serve to bring technology for the production of OMC to South Africa.

A strategy of entering into long-term strategic partnerships or alliances with existing menthol and OMC producers would secure off-take from the proposed business.

14.7 Ability to research, develop and commercialise new Aroma and Fine Chemicals

It is a necessity for a new producer to have access to a capability of researching, developing and commercialising new aroma chemicals in order to own a balanced technology portfolio and for growing the future business. The ability to rapidly respond to changing customer requirements or to fill an identified gap in the market requires a high level of innovation. For those companies with limited resources developing and commercialising new products will be a problem.

Given the fact that South Africa's system of innovation currently represents less than 1% of global innovation activity, there will most likely always be a source of new technologies that should be accessible for adaptation or improvement within the South African environment. In addition, a number of small volume high-value aroma chemicals which have the potential to add to the portfolio outlined in this study have been identified. Examples include the menthol derivatives such as menthyl isovalerate and menthyl acetate, zingerone, heliotropin, p-anisyl alcohol and musk ambrette to name a few. These products would add to the product portfolio and potentially establish a platform for future innovation of novel aroma chemicals.

Little work has been done internationally on developing any analogues of menthol. The industry would like to see the effect of modifying the basic structure of the menthol molecule and how these modifications could affect both odour and the cooling effect.[53] Development of these products into commercializable technologies will require funding. The later stages of innovation (scale-up, product introduction, process engineering, and new plant trials) are expensive and remain technologically risky.

Recent research has shown that the commercialization of new chemical processes in South Africa is not efficient. Innovations, patents and technology transfer are not sufficiently rewarded as core tasks of academics and researchers at academic institutions.[54] This focus is reflected in the relatively low number of patents per South African scientist. Start-ups are derived at a low level of 2 per 100 patents in South Africa, *vs* the international norm of 10 to 15 start-ups for every 100 patents.[55] The latest customized sectoral research undertaken by the Department of Trade and Industry identified a lack of skills in the chemical sector, amongst these in the field of research and development technicians.

In addition, the recent Emerging Biotechnology Roadmap found that a substantial financial gap to bridge the chasm between innovation and commercialization remains. Funds are too limited and the time frame for funding is often too short. [56] The same can be said for downstream chemical industry. Whilst there are a number of existing financing instruments in South Africa criteria applied limits funding sources available for research and innovation for new start-up companies, or companies without substantial existing international exposure. Typically, the criteria requires the project to demonstrate a large degree of radical innovation, whilst at the same time insisting that applicants provide take-off agreements from potential customers. In the aroma, flavour and fragrance industry, it is unlikely that any commercial partner would commit to purchasing product before being supplied with material obtained from pilot plant trials, and substantial guarantees that commercial production would commence within a reasonable timeframe.

In addition, current sources of research funding often do not consider process innovation to produce known or existing products, sufficient to provide a competitive advantage, often insisting on new innovative end-products. Yet in direct contrast, there is a prerequisite that the commercial partner should have demonstrated substantial experience in manufacturing

[53] G.S. Clark: Perfumer and Flavourist; Vo. 23, 1998
54 Draft Emerging Biotechnology Roadmap: Department of Science and Technology: November 2003
[55] National Biotechnology Audit: September 2003
56 Draft Emerging Biotechnology Roadmap: Department of Science and Technology: November 2003

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or marketing the product or similar product. The general risk averseness on the part of financiers and the lack of appropriate Venture Capital funders therefore severely hampers the creation of new value chains or new enterprises based on utilizing current sources of research or indeed even the creation of new value chains based on innovative technologies.

It is widely accepted that 9 in 10 SMEs in South Africa fail within the first two years of operation.[57] Research conducted by the European Union, concluded that business incubation is one of the leading strategies to enhance the overall survival rates of SMEs. In developing countries, incubation survival rates tend to rank above 85% in countries with strong support from the Government and tight links with the University/Tertiary system. The relatively low cost per job compared with other public means and programmes and other quantifiable benefits demonstrated by business incubators covered by research suggest that they are very effective methods of promoting knowledge intensive, new technology-based activities. There is therefore strong evidence to suggest that incubator initiatives can contribute to the building of an Aroma and Fine chemical value chain by increasing the success rate of start-up companies.

[57] Godisa News: February 2002: Business Incubation “ the ultimate way to increase the survival of SMEs”

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