STUDY INTO THE ESTABLISHMENT OF AN AROMA AND FRAGRANCE FINE CHEMICALS VALUE CHAIN IN SOUTH AFRICA (TENDER NUMBER T79/07/03)

FINAL REPORT
(Submission Date: 15 September 2004)

Part One/Four-
Report: Executive Summary

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PART 1 – EXECUTIVE SUMMARY

This Report has been divided into four separate Parts. Each Part is self-contained and self-explanatory.

Part One-
Executive Summary

Part Two-
Report: Aroma Chemicals Derived from Effluent from the Paper and Pulp Industry

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PART 1 – EXECUTIVE SUMMARY

1 INTRODUCTION

The Fund for Research into Industrial Development, Growth and Equity (FRIDGE) proposed a study into the establishment of an aroma and fine chemicals value chain in South Africa. The investigation had the following broad objectives:

1. To review the AECI proposed synthetic Aroma and Fine Chemicals portfolio as a basis for establishing a viable Aroma and Fine Chemicals business and hence for potential commercial development;
2. To include a study on the potential use of effluent from the paper and pulp industry as a raw material for Aroma and Fine Chemicals products;
3. To include a study on the potential synergy between developing synthetic Aroma and Fine Chemicals production facilities and developing South African natural sources of Aroma and Fine Chemicals.

A key focus of the study was to assess the attractiveness of local manufacturing and to produce a clear picture of labour requirements and expected number of jobs that would be created.

The detailed terms of reference and the specifics of each aspect of the Study are set out in Chapters Two, Three and Four.

Flavour and Fragrance industry

Formulations of flavour and fragrance from Aroma chemicals are used globally for imparting attractive taste and aroma to processed foods and beverages and adding pleasing scents to perfumes, toiletries and detergents. The world-wide Flavour and Fragrance industry generally earns returns in excess of the chemical industry average. The industry's close association with the health, personal care and food and beverage markets means that its revenues are relatively stable, largely insensitive to commodity cycles and relatively recession-resistant.

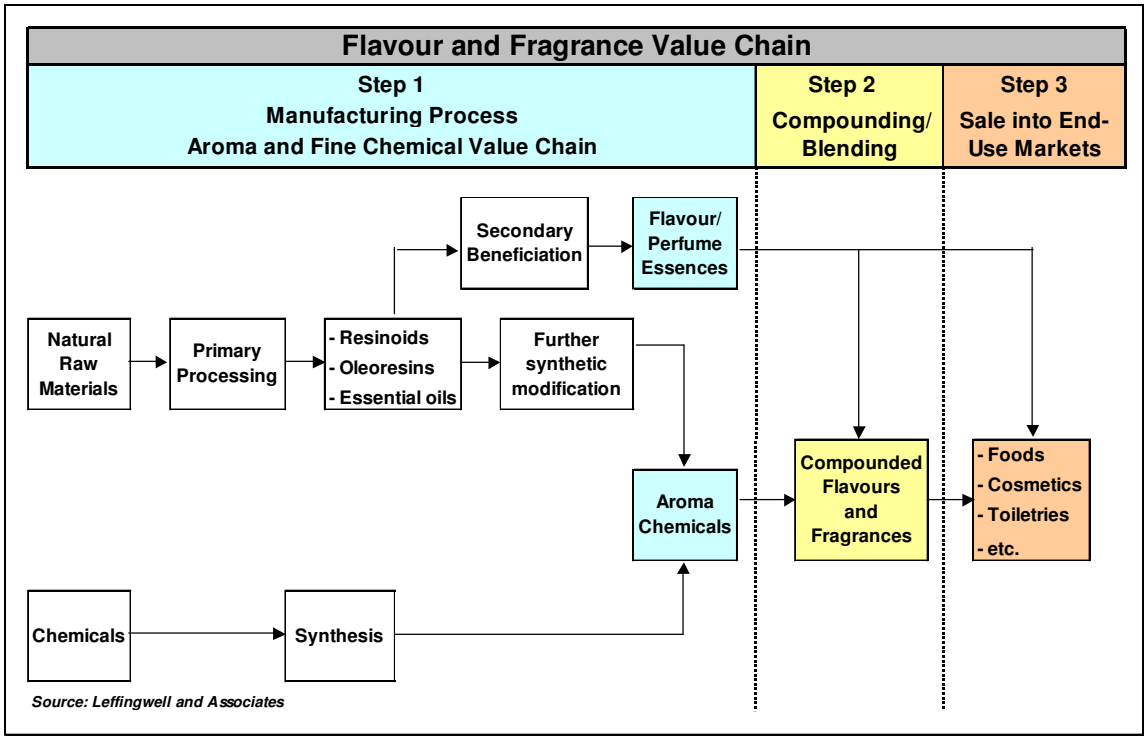
The industry is segmented broadly into three areas:

1. Isolation of synthetic and natural aroma chemicals or essential oils/natural products. (Aroma Chemicals are single, chemically defined substances which act on the senses of smell and taste; and essential oils are naturally occurring, volatile products obtained from various parts of plants.)
2. Compounding of these products into flavour and fragrance formulations tailored to meet specific customer requirements. The formulations may contain aroma chemicals as well as essential oils and natural extracts.

3. The sale and use of these formulations in the production of personal care and pharmaceutical active ingredients, food and beverage markets etc.

The full Flavour and Fragrance value chain is represented in figure 1.

FIGURE 1: Flavour and Fragrance Industry Value Chain



The contribution of the various components of this value chain is illustrated in Table 1.[1]

Table 1: Value of the Flavour and Fragrance Industry 2002

	% of the Value Chain	$ Billion
Aroma Chemicals	12%	1.8
Essential Oils and Natural Extracts	12%	1.8
Flavour Compositions	41%	6.2
Fragrance Compositions	35%	5.3
TOTAL	**100%**	**15.1**

[1] C&EN Estimates May 2002/Leffingwell and Associates

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The value of essential oil and other natural extracts are equal in value to those of aroma chemicals estimated at US$1.8 billion each in 2002. Trade in essential oils and related products are growing at roughly 10% per annum whereas the overall flavour and fragrance market is growing at between 4% and 5% per annum.

Over 75 % of the industry's value however lies in the composition of the flavours and fragrances. Large international Flavour and Fragrance houses specialize in the compounding of flavour and fragrance products. Most major participants in the Flavour and Fragrance industry operate internationally and maintain a presence in virtually all markets of the globe. Over recent years there has been a large amount of rationalization and consolidation within the industry and this process is likely to continue. Twelve international flavour and fragrance companies hold over 65% market share. One major reason for this is that of the cost of owning an adequate infrastructure, which includes the cost of toxicological testing, research and development, quality control, and efficient manufacturing and marketing, is so high that only the largest of companies can afford it. The costs associated with these activities also explain the reason for the high value associated with this segment of the market.

These substantial barriers to entry make the development of the formulation segment of the value chain (Step 2) as the basis for establishing an Aroma and Fine Chemical value chain very difficult. This Study therefore primarily focused on products belonging to Step 1 of the overall value chain, henceforth referred to as the Aroma and Fine Chemicals Value Chain. Once Step 1 has been successful, consideration could be given to extending the industry into Step 2.

Aroma Chemicals

Aroma chemicals can be classified according to their chemical structure. The main groups and their share of the aroma chemical market are detailed in Table 2.[2]

Table 2: World Consumption of Aroma Chemicals in 2002

	Percentage by Value	Percentage by Quantity
Benzenoids	34	48
Terpenes/Terpenoids	37	34
Musk chemicals	13	7
Other aroma chemicals.	16	11
	100	100

[2] SRI Chemical Economic Handbook 2003

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There are about 2,800 aroma chemicals approved for use in flavour and fragrance formulations world-wide. However, only a few hundred are produced in volumes over 50 tons for the merchant market. The aroma chemicals under consideration in this study fall into the categories of either benzenoids or terpenoids.

Aroma Chemicals can be manufactured *via* a number of different routes:

1. **True synthetic chemicals**: This includes chemicals produced by synthesis from natural aromatic compounds and from synthetic feed stocks e.g. petrochemicals.

2. **True Isolates**: Single aroma chemicals, which are extracted from natural materials and subjected only to further processes of purification. These include the following: camphor, citral, and menthol.

3. **Chemically modified derivates:** Made by converting an isolated product into a different chemical by subjecting them to various chemical processes. This includes the conversion of crude sulphonated turpentine, a by-product of the Kraft paper pulping process, into terpene aroma chemicals such as citral and linalool. It also includes vanillin produced from lignin, a by-product of the paper pulping process.

This FRIDGE study includes an assessment of these three areas for determining suitable local manufacture routes and raw materials for an optimum portfolio of aroma and fine chemical products with which to establish an Aroma and Fine Chemicals business. The starting point was to review the extent to which AECI's previous efforts into development of an Aroma and Fine Chemicals business could contribute to identifying such an optimum portfolio.

Commencing in the late 1980's, AECI had identified certain Aroma and Fine Chemicals, which it believed could form part of a new fine chemicals business. AECI carried out an intensive research and development programme over a period of more than ten years, aimed at developing competitive manufacturing technologies for selected Aroma and Fine Chemicals produced from petrochemical feed stocks and effluents from the pulp and paper industry. The strategic intent was to become a leading global producer of selected products, supplying a basket of aroma chemicals to flavour and fragrance houses for formulation. AECI's focus was therefore the manufacture of true synthetic chemicals and chemically modified derivatives as referred to above.

During 1998, AECI decided to scale down its wide-ranging in-house research and development programme, and outsourced further work on Aroma and Fine Chemical technology development to the CSIR. Together with the CSIR, AECI developed an Aroma

and Fine Chemical portfolio constructed around the use of petrochemical based feed stocks. The suite of products studied was based on a novel and potentially competitive process for the production of p-hydroxybenzaldehyde (pHB) and p-anisaldehyde (pAA). This technology, using a mixed cresol stream as the key feedstock selectively converts p-cresol to pHB in the presence of m-cresol. This feature of the technology gives it a unique business advantage, as a number of commercially available mixtures of m- and p-cresol could be used as feedstock. The separation of m- and p-cresol from these mixtures by traditional means is a costly and capital-intensive process.

The products proposed for commercialization were selected on the basis that they were large volume Aroma and Fine Chemicals, serve actively growing end-use markets, had low risk of substitution, and did not require lengthy and costly registration processes for product approval. The products are strongly inter-related in terms of market areas and customers. This synergy would offer the opportunity to access markets and customers, which may find a basket of related products from one supplier attractive. The products and their market synergies are depicted below.

FIGURE 2: Market Areas and Synergies of Proposed Product Portfolio

Product	*Precursor for other Aroma Chemicals*	*Flavour and Fragrance Ingredient*	*Personal Care Active Ingredient*	*Pharma. Active Ingredient*	*Precursor for Pharma. Active Ingredients*
p-hydroxybenzaldehyde (PHB)	√				√
p-anisaldehyde (PAA)	√	√	√		√
Raspberry Ketone (RK)		√			
p-anisyl alcohol		√			√
thymol	√	√	√		√
menthol		√	√	√	√
menthyl acetate		√			
racemic menthol			√	√	
vanillin		√			√
ethyl vanillin		√			
Trimethoxybenzaldehyde (TMB)					√

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During 2001, in line with a wide-ranging business transformation process, AECI took a strategic decision to exit from its fine chemicals development programme, and to offer the know-how and technology, which had been developed to interested parties. AECI reached agreement with the CSIR during 2003. The CSIR now owns the technologies in respect of the proposed portfolio of Aroma and Fine Chemicals.

Using the AECI portfolio as a reasonable basis, the FRIDGE study benchmarked the competitiveness against lead international players of locally manufacturing the aroma products from raw materials derived from petrochemical feed stocks and the paper and pulp industry, deploying, depending on applicability, either CSIR developed technologies, commercial processes or process routes extracted from information in patents and open literature to arrive at a recommendation on an optimum portfolio and possible business structure. The proposed aroma business formed the framework within which to define key success factors for establishing the Aroma and Fine chemicals value chain, and dimension innovation requirements, job creation potential and skills gaps.

Essential Oils

Essential oils are naturally occurring volatile products obtained from various parts of plants: for example fresh or dried fruit, leaf, bark, root or seed. Essential oils are usually extracted from the plant material by steam distillation, expression, or solvent extraction. The amount of oil extractable ranges from an infinitesimal quantity to as much as 1-2% of the dry weight of the plant material distilled. The typical essential oil is a complex mixture of chemical compounds, each of which possesses its own, individual set of properties. The odour of the oil can be due mainly to one single chemical constituent, or to a mixture of several odoriferous chemical bodies. The chemical constitution of the bodies may not always be known.

There are approximately 160 essential oils traded globally. The top 10 oils make up some 80% of the world trade. The world trade in essential oils may therefore be divided into two components, often referred to as the major and minor oils. Major oils are those oils traded in large quantities (but often lower prices). The remaining 150 minor essential oils are of higher value but are traded in quantities ranging from a few kilograms per annum to a few hundred tons per annum. Competition in the major essential oils is strong with the low cost producers of Asia and South America dominating, whereas the demand and prices for the minor oils is steadier.

True isolates are single aroma chemicals extracted from natural materials. Most isolates are extracted from essential oils, however only some 20% to 25% of essential oils are used for the production of isolates. Hence, although it is possible to isolate aroma chemicals from

essential oils this is generally only done in respect of the major oils, where economies of scale allow for the natural isolate to compete with the synthetic counterpart. The remainder minor essential oils are used “as is” by the same industries that use the isolates. Their attraction is in their complex chemical structure and consequent organoleptic properties they possess. Alongside synthetic aroma chemicals, the essential oils industry makes up an important component of the flavour and fragrance supply chain. Sales of essential oils and other natural extracts were equal in value to those of aroma chemicals in 2002. Most naturally derived aroma chemicals have their synthetic counterpart; however there has always been a niche for the natural products.

Over the last 50 years the demand for essential oil products has gradually increased due to the rise in the world population and a desire for greater food variety by industrialized countries. An increasing concern for the environment and for the safety of food, coupled with the general difficulty in manufacturing synthetic alternatives has also contributed to the growth in demand for essential oil products. The major consumers are the U.S. (40%), Western Europe (30%) and Japan (7%).

The primary production platform for essential oils is agriculture requiring a high level of horticultural expertise to grow crops with consistent and correct quality. The technology associated with extraction of the essential oils is relatively simple, but the knowledge and skills base required, ensuring best yields and high quality oils, are of primary importance. It is mastery of the entire value chain that allows differentiation between a mere bulk producer and a world class supplier of essential oils capable of integrating activities with international flavour and fragrance houses.

This Study has not dealt with the detail of the agricultural aspects of essential oil production but has focused on the overall dynamics of the industry. The Study reviewed the global essential oils industry and, in considering the current emerging South African essential oil industry, proposed a portfolio, which could be attractive to growing the industry in South Africa. The Study also looked at potential synergies with an Aroma and Fine Chemicals business, dimensioned the key success factors and determined the potential for job creation.

2 CONCLUSIONS

2.1 Aroma Chemicals derived from Petrochemical Feed stocks

Based on the AECI/CSIR technologies, the techno-economic analysis for an optimised Aroma and Fine Chemicals portfolio, produced from a mixture of a petrochemical based, meta- and para-cresols feedstock, within the context of the South African fiscal and economic environment, identified two potential economically viable business cases for establishing a local Aroma and Fine Chemicals value chain:

1. A fully integrated business producing 1,500 tpa menthol, 2,000 tpa OMC (octylmethoxycinnamate), 381 tpa technical grade pAA and 200 tpa flavour grade pAA.

2. An upstream bulk intermediates business displaying commodity type characteristics, producing 1,720 tpa pAA and 2,000 tpa m-cresol, coupled with a dedicated downstream Aroma and Fine chemicals business consuming the pAA and m-cresol, to produce 1,500 tpa menthol and 2,000 tpa OMC.

A value chain analysis of the proposed portfolio of products (listed in Figure 1 in the Introduction) concluded that the key business drivers are pAA and menthol, produced from m-cresol. Other products produced from pHB are not major drivers. The manufacture of menthol must therefore be included in the product portfolio in order to fully realise the benefit of the CSIR's novel technology. The major market for pAA is OMC, an active ingredient in sunscreens. Access to this market is therefore critical.

A product portfolio excluding menthol and OMC will however not meet investment hurdles. The inclusion of either vanillin or ethyl vanillin detracts value from the project, and should only be considered if no further capital investment for the manufacture of these two products was required.

The optimal portfolio for Aroma and Fine Chemical value chain was hence defined and the capacities for the optimised product portfolio determined to be world-scale. These capacities are within the parameters required for economies of scale. The output of this optimized portfolio is R 325 million[3] per annum for an Inside Battery Limit capital expenditure in the order of R 230 million.[4] Outer Battery Limit services, utilities and infrastructure would be required in addition to this investment. A world-class site capable of supplying these

[3] At an exchange rate of R 7.00/US$

[4] Based on CSIR Inner Battery Limit factored estimates of fixed capital investment (± 30% accuracy) in 2004 money, adjusted for the proposed capacity using a scale-factor. For individual Inner Battery Limit plant areas, a process development allowance factor (process contingency dependent on the status of the development of the technology) has been determined and applied to the fixed capital investment for each.

services and utilities at competitive prices is therefore required. This site should also have the potential for expansion and must in addition maintain the highest environmental and safety standards. Due to the stage of technology development for the product portfolio, this investment has not been dimensioned.

A producer of the proposed portfolio of products will have to compete with well-established major players in these markets. To become globally competitive, it would therefore have to generate a significant and sustainable competitive position to succeed. Benchmarking exercises against the world leaders were therefore conducted on an international basis (US$) for stand-alone plants on a cash cost basis. This approach was adopted in order to determine the inherent and fundamental sustainable competitiveness of the technologies.

The Study concluded that the technologies for pHB, pAA and menthol are internationally competitive against the world leaders provided that a mixed cresol feedstock price, equivalent to a pure cresol price of $ 1,250 – 1,458/ton is obtained and the m-cresol price credit exceeds $ 1,800/ton. The technologies for vanillin and ethyl vanillin are however not competitive against the major world producers.

The Study furthermore indicated that a far greater stumbling block than competitiveness against the pAA market leader is the pAA prices required by the end-user OMC producers to compete with the cost leader in this market. The OMC market leader uses a different and more competitive process. These pAA prices are extremely low compared to market prices and it is doubtful that these prices could be matched on a plant based on any current or developed pAA technologies. A South African fully integrated OMC producer using internationally competitive technology could however be competitive against the world leader at the indicated mixed cresol and m-cresol prices. This Study therefore concluded that a South African pAA producer should be fully integrated through to the production of OMC in order to compete. Technology for the production of OMC from pAA has not been developed in South Africa. Furthermore, it is still covered by patent protection.

The overall pHB process has been demonstrated sufficiently at pilot scale on a MP99 feedstock (50:50 m:p ratio) to full design specification. MP96 and MPX feed stocks have been evaluated on a more limited experimental scale. Hence some further test work would need to be carried out in order to fully specify a plant based on MP96 or MP99 (60:40 m:p ratio). The pAA process has been fully developed at pilot scale. The only issue is the choice of methylating agent, a site related issue, which would affect the flow sheet configuration.

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The menthol technology is owned by and can be licenced from Mbuyu Biotech (Pty) Ltd.[5] Menthol is produced from m-cresol *via* thymol as the precursor. The thymol front-end technology has been developed at bench-scale, but considerable pilot work is still required. The process for conversion of thymol to menthol has been developed to early stage pilot scale. Further pilot plant development work will be necessary before a commercial scale plant can be designed and fully specified. Pilot plant quantities of menthol for product evaluation by major flavour and fragrance houses have been produced.

The aroma chemical industry is characterised by the difficulty of penetrating the international market. Aroma chemical formulations are developed around a particular specification or organoleptic quality acquired from a certain source of the ingredient. It is therefore very difficult for the end-user to change its source of supply once a product is formulated. Securing market access and establishing long-term customer relationships is critical to success in this value chain. This is particularly valid for menthol and OMC, the key drivers within the proposed suite of products.

The number of direct jobs that will be created by expanding output through implementing the optimized portfolio for the petrochemical Aroma and Fine Chemicals value chain will be in the range of 140 to 150. The occupational distribution and skills requirements of the Aroma and Fine Chemical value chain mirror those of the overall chemical industry sector in general. Typical skills required include: batch processing, small plant operation, product formulation, and industrial chemical synthesis.

A number of small-volume high-value Aroma Chemicals, which could be added to the portfolio of products in this value chain, have been identified. These include zingerone, heliotropin, p-anisyl alcohol, musk ambrette and menthol derivatives such as menthyl isovalerate and menthyl acetate. These products may be more suited to production by SME type businesses.

This study determined that the key success factors for the goal of establishing a globally competitive and sustainable Aroma and Fine Chemical value chain are the following:

- Erecting world-scale plants as business clusters for selected products, rather than a few disparate small operations;
- Implementing leading edge technologies and operations;
- Accessing secure and competitively priced key raw materials;
- Producing product of consistent quality and quantity;
- Securing market access and,
- Constantly innovating and introducing new products into the portfolio.

[5] Permission was obtained by Mbuyu Biotech (Pty) Ltd for the FRIDGE study to include the analysis of menthol in the product portfolio.

Although this FRIDGE study clearly demonstrated that South Africa has access to an internationally competitive suite of enabling technologies relevant to the production of a portfolio of Aroma and Fine Chemicals, it also highlighted the fact that South Africa lacks a number of critical factors required in order to implement this new value chain.

1. South Africa has a shortage of suitably trained personnel capable of developing and implementing competitive fine chemical technologies. [6]
2. The ability to meet the organoleptic requirements of the customer depends on the skills of a "flavour" chemist or olfactory expert. These skills are however practically impossible to recruit in South Africa.[7]
3. A substantial financial gap to bridge the chasm between innovation and commercialisation remains. Funds are limited and the expected time frames for return on investment are generally too short.[8]

Based on the project techno-economics of the optimized product portfolio and the demonstration of a suite of competitive technologies, commercialization of this value chain could therefore represent an attractive opportunity for South Africa as a platform for the launch of an Aroma and Fine Chemicals value chain in South Africa. However before this can be achieved, the constraints impeding the creation of this value chain must be removed in order to prevent the technologies moving offshore to countries or companies where these limitations do not exist and so potentially denying South Africa from benefiting from the opportunity to locally commercialise in-house developed novel technologies.

2.2 Aroma Chemicals Derived from Effluent from the Paper and Pulp Industry

The development of a vanillin business based on production from lignin produced as a by-product in the paper and pulp industry is currently not viable. The viability of the technology would depend on a higher yielding feedstock being identified. Trends within the paper and pulp industry in South Africa indicate that it is unlikely that a sustainable source of this feedstock will be identified. However, in the event this feedstock is identified, the technology would however not offer a means of reducing any environmental problems in the paper and pulp industry as a substantial stream of black liquor must still be returned to the mill.

[6] 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.
[7] 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.
[8] Draft Emerging Biotechnology Roadmap: Department of Science and Technology: November 2003

The assessment of the terpene aroma chemical size has concluded that the size of this business in the international context will be very small, with a maximum potential turnover in the region of R 7 million. This size of business is therefore suited to a SME-type business. An order of magnitude capital estimate of R 11.6 million has been determined for a 420 tpa crude sulphonated turpentine plant based on export of the plant's full output. This can be compared with the estimated affordable capital in the range of R 7.5 – 9.7 million.

There is however no guarantee that the annual supply of crude sulphonated turpentine at this level is sustainable. The feedstock supply at this point in time can only be guaranteed at the 180 tpa level.

The assessment of a terpene aroma chemical business based crude sulphonated turpentine feedstock available from the paper and pulp industry in South Africa has thus concluded that if a minimum supply of 360 – 420 tons crude sulphonated turpentine annually can be guaranteed, an investment case is potentially feasible. If a lesser amount of crude sulphonated turpentine is available annually, from 180 to 360 tons, there may be a potentially viable case for using existing facilities However, due to the early stage of definition of the processes involved in the production of the terpene aroma chemicals, before a final investment decision can be made, a more accurate techno-economic model would have to be developed.

2.3 Aroma Chemicals Derived from Essential Oils

South Africa has a long involvement in the essential oil industry with regards to the production of major essential oils like eucalyptus and citrus oils, supplying some 5% and 2% of the world market respectively. These industries are however under severe pressure from the low cost producers (e.g. China and Brazil) and the strengthening of the Rand. South Africa has a fledgling essential oils industry in the production of the higher value minor essential oils (e.g. geranium, chamomile and lavender) that was pioneered by the CSIR.

It is estimated that South African production of essential oils and related plant extracts is between R 60 - 100 million, of which only R 10 - 15 million is attributable to the minor essential oils. Although there are some 100 local producers, only a dozen commercial producers and a couple of development projects consistently supply the market. The number of operational distillation units is estimated between 30 and 40, many of which are too small for economic production. Locally produced essential oils are generally sold to two or three of the local companies that have been able to penetrate the international export market. Low volumes of smaller quantities of oil are sold into the growing local aromatherapy market.

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It is widely accepted that South Africa has many indigenous plants that have potential commercial value. However, to exploit these commercially on an international scale one needs to move from wild-harvesting to cultivation in order to ensure sustainability, in terms of quantity and quality. There is a common misconception that there is a ready market for new and novel products. The reality is that the market is very conservative and market acceptance of a new product must be coupled with an intensive development programme. The initial demand must be created, and issues such as safety, quantity and quality addressed. With regards to essential oils from indigenous plant materials, there are several plants showing some promise, including Artemesia and Cape Chamomile. However, it is only Buchu that has enjoyed any international success. Shortage of supply and an over-reliance on wild harvesting has however placed this industry under pressure in recent times.

The Study concluded that before a new producer can commercialise new aroma, fragrance and flavour compounds from indigenous plant material, it must first establish itself as an internationally recognized producer of accepted essential oils. The establishment of an essential oil industry in South Africa could therefore be seen as "school fees" in the creation of a longer-term indigenous aroma chemical industry.

Although there are no unique grounds upon which South Africa can claim competitive advantage in the global essential oils industry, there is a combination of factors that are in South Africa's favour. These include:

- Being in the Southern Hemisphere – many growing regions are in the Northern Hemisphere; the seasonal effect makes Southern Hemisphere suppliers attractive.
- Traditional strong trade links with Europe, a major importer of flavour and fragrance materials.
- Being established as a world class agricultural producer in a wide range of products.
- A diverse climate with a range of biomes - thus allowing for a good selection of essential oil crops to be grown.
- Good quality soils – being largely uncontaminated by centuries of exploitation as is the case in the developed world.

However, in spite of these competitive advantages and substantial interest from international buyers, South Africa has not yet established itself in the international essential oils market.

The CSIR initiated the interest in the essential oil industry almost ten years ago, doing research work in conjunction with local commercial farmers. However, over time various technical difficulties were encountered and many producers began to feel that the CSIR's consulting terms were too onerous. As a result, an independent association, the South African Essential Oils Producer Association, was formed in 2000 in the Mpumalanga Province and now has a branch in each of the Kwazulu Natal and Western Cape Provinces.

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The Association has achieved some nominal success, but is generally considered by stakeholders to be under funded and disorganised. The Association endeavours to provide basic production information and support to growers. The Association has identified that the main industry constraints are achieving sufficient production volumes, so as to attract international buyers, and access to chemical analytical facilities to monitor and control quality.

The CSIR has reduced its involvement significantly, although it retains some peripheral involvement in that it supports some community development projects (e.g. Giyani in the Limpopo Province). No one organisation has taken over the CSIR's role as lead agent in promoting the essential oil industry from a research and development perspective. Each of the Agricultural Research Council and the National Botanical Institute has some peripheral involvement (the later in the case of indigenous plant species). There are several other institutions, most linked to Universities (such as the Natural Resource Institute at the University of Kwazulu- Natal), which have ad hoc programs that producers can draw support from. However, there is no concerted public research and development program and practically no publicly available information. There are various Government Departments (inclusive of the Department of Industry, the National Department of Agriculture and the Department of Science and Technology) that have newly established posts focusing on the essential oil industry, but these have not yet been co-ordinated. The fragmentation and lack of co-ordination in the industry are constraining factors on the growth of the industry.

One of the major contributing factors for the abovementioned fragmentation is that the essential oils industry falls across two industry sectors (the agricultural and chemical sectors). This has lead to some confusion as to how, and by whom, the industry should be supported.

The Study's analysis of the essential oil value chain identified four separate stages. It is not possible to consider the creation of an essential oil industry in South Africa without considering the complete value chain.

1. **Agricultural - Crop selection and Crop Cultivation**

   A large component of the value chain is agricultural. Industry stakeholders are unanimous in their view that unless the volumes of quality oils are increased the economies of scale required to encourage later stage innovation and beneficiation of essential oils will not materialise.

2. **Primary Processing (e.g. Drying, distillation)**

   This first step is aimed at achieving the best quality and quantity of product. Although the primary process currently utilized in South Africa is steam distillation, there is a trend internationally towards more sophisticated extraction processes.

Although technology associated with primary distillation is relatively simple, good distillation practices are required to ensure the best yields and quality of oils. Furthermore, without fully understanding the manner in which the distillation process can affect quality it is not possible to improve processing thereby optimizing quality.

3. **Secondary beneficiation (e.g. Rectification, Fractionating, Formulations)**
   This area distinguishes a world-class supplier of essential oils from a mere "bulk producer" of essential oils. The strength of a local industry is therefore dependent on its ability to integrate its activities directly with the international flavour and fragrance houses. This requires continued exposure to the international players and an increasing level of technical sophistication.

4. **Sales and marketing**
   Most end users have a very specific specification for their ingredients and formulations are often developed around a certain source of the ingredients. "Breaking" into this market is therefore difficult. However, once relationships have been developed stability of off-take is assured, provided that the specifications continue to be met.

The issues confronting developing countries endeavouring to upgrade their essential oils industry are very similar. Analysis of these issues as well as the value chain above, has led to the identification of a number of critical success factors for the development of a successful essential oils business and industry.

1. There must be a sustainable and significant **quantity** of the correct **quality** essential oil being produced. Besides horticultural issues, there needs to be careful quality control. Each oil has a minimum level of production (before international buyers will seriously consider a commitment) requiring the availability of good genetic material, production systems, post harvest treatment, distillation practices and storage and handling practices.

2. **Market focus** is critical. Close relationships with international customers, particularly large flavour and fragrance houses, are essential. This requires a reputation in the market place (both as individual companies and as a producing region committed for the long term), knowledge of regulatory parameters and trends, industry quality standards and testing procedures, and understanding of the market dynamics.

3. There must be a high level of **technical service**. Substantial chemistry and organoleptic skills and experience are required. This requires local commitment to ongoing research and development as well as skills development and training.

Consideration was given to the selection of essential oils that would make attractive options for commercial production in South Africa. Whilst it is theoretically possible to perform an economic analysis of all the oils that could potentially be grown in South Africa and then to rank these by profitability, there are so many variables that the exercise would be largely academic. Furthermore, agricultural decisions are quite complex.

The Study has therefore focused on the creation of a long-term sustainable producer base for a wide range of oils and compiled a Primary and Secondary list. The Primary List contains the mainstream crops with sufficient market knowledge and technical support available to see success in the short-term. The Secondary List contains oils that may be of interest to broaden the production base in South Africa. The list excludes bulk oils (such as eucalyptus and citrus) as South Africa already has a significant presence in these markets. Based on these lists, it is estimated that South Africa could generate an additional R125 million per annum in turnover over the next three to five years. Job creation resulting from the development of this industry will predominantly be in the agricultural sector; however it will provide approximately 10 jobs in the downstream chemical processing areas of analytical chemists, laboratory assistants and process operators.

TABLE 3: Proposed list of attractive essential oil crops

Proposed Primary List	Proposed Secondary List
Geranium	Spearmint
Roman Chamomile	Peppermint
German Chamomile	Parsley Seed
Rosemary Oil (verbenone type	Jasmine
and cineol type)	Tuberose
Lemon Balm (Melissa)	Marigold
Marjoram	Celery Seed
Thyme oil	Vetiver
Basil oil	Cassie (Mimosa)
Lavender Oil	Yarrow
Lavandin Oil	Dill
Lemon grass	Tarragon
Buchu	Coriander
	Fennel
	Vaerian
	Helichrysuam

The Study has therefore concluded that the further development of the essential oil industry would be a valuable complementor to an Aroma and Fine Chemical industry. Furthermore, the essential oil industry could act as a precursor to the successful commercialisation of a wider range of South African indigenous plant products. Whilst the basis for a profitable and

sustainable essential oils industry in South Africa already exists, the industry has not yet reached critical mass and is not sufficiently mature enough to gain international prominence. However, there is a real opportunity to develop this industry in South Africa.

In order to realize this opportunity, the industry must be better supported. The consensus amongst industry players is that Government has a key role to play in developing the industry. This would primarily involve the areas of research and development, and the development and enhancement of education and information systems.

2.4 Prospects for the Development of an Aroma and Fine Chemicals Value Chain in South Africa

The first step in the Flavour and Fragrance industry value chain is the isolation of synthetic and natural aroma chemicals or essential oils/natural products. These products are then compounded into formulations tailored to meet specific customer requirements by flavour and fragrance houses. The end-users, purchasing compounded products, are companies in the personal care, pharmaceutical, food and beverage markets. This value chain is outlined in Figure 1 above.

International flavour and fragrance houses have both natural and synthetic product offerings. One of the key drivers of success in the Aroma Flavour and Fragrance Fine Chemicals market is the ability to offer a range of products, which includes synthetic and natural products. Natural aroma chemicals can be isolated from essential oils where economies of scale allow for the natural isolate to compete with the synthetic counterpart. Essential oils are also traded and used more or less “as is”, their attraction being in their complex chemical structure and consequent organoleptic properties. Table 1 indicated that the aroma chemicals and essential oils/natural extract markets internationally were valued equally at $ 1.8 billion in 2002. The growth of the essential oils market worldwide is close to 10% per annum, more than double that of the synthetic Aroma Chemical market.

The essential oils industry can clearly therefore be seen as complementary to the synthetic aroma chemical industry. The establishment of a synthetic aroma chemical industry in South Africa would thus be well served by the parallel development of an essential oils industry. In addition, the development of a South African essential oils industry could form the platform for the future commercial exploitation of South Africa’s indigenous plant materials. These botanically derived chemicals are destined for the same markets as the synthetic specialty and fine chemicals. These markets include the flavour and fragrance industry, the cosmetics industry, the health industries and pharmaceutical industries. The success of this industry will be largely dependent on the continued growth of the core synthetic bulk and fine chemical industry.

In the long term, the Aroma and Fine Chemical value chain described, comprising both synthetic and natural products, could form the basis for integration into a South African flavour and fragrance compounding industry. Although, barriers to entry are high, many cosmetics and toiletries multinationals have located production facilities in South Africa as a production base for the Sub-Saharan region. The growth of local and regional tastes and fragrances, which may not be serviced by international suppliers, could provide an opportunity for the growth of a South African and regional flavour and fragrance compounding industry.

The market for flavours and fragrances in South Africa and Sub-Saharan Africa in 1999 and projected for 2004 is shown in the table below.

Table 4: Market for Flavours and Fragrance in South and Sub-Saharan Africa: 1999 – 2004[9]

End-use ($ millions)	South Africa		Sub-Saharan Africa	
	1999	**2004**	**1999**	**2004**
FLAVOURS	56.7	67.5	59.5	77.8
Growth Rate		*3.6%*		*5.5%*
FRAGRANCE	50.6	57.8	52.3	66.5
Growth Rate		*2.7%*		*4.9%*
GRAND TOTAL	**107.3**	**125.3**	**111.8**	**144.3**

This figure for the South African total market in 2004, $ 125.3 million (R 877 million)[10] has been confirmed by industry sources. The regional South and Sub-Saharan African market in 2004 was expected to be in the order of $ 279 million (R1,887 million). Growth in the region is anticipated to continue to be strong. Thus the timing for the creation of a local flavour and fragrance industry is good.

The creation of a South African Aroma and Fine Chemical industry, which includes both synthetic aroma chemicals and essential oils, would increase the potential of greater participation in the growth of the local and regional flavour and fragrance market. The increased availability of local Aroma Fine Chemical and essential oil products may well encourage local companies to enter or expand into this sector of the market. The industry is

[9] An Overview of the Global Flavours and Fragrances Market: IAL Consultants 2000
[10] At an exchange rate of R 7/US$

currently dominated by the large international flavour and fragrance houses, importing mostly compounded products from either their parent company, or other large houses. Thus, the opportunity to develop a South African flavour and fragrance industry formulating locally produced active ingredients into niche markets could be developed.

2.5 Cross-Cutting Issues

The three focus areas of the Study have identified a number of crosscutting issues that will drive or impede the creation of an Aroma and Fine Chemicals value chain in South Africa.

2.5.1 Skills development

A recent Chieta Skills Needs study [11] concluded that South Africa has a shortage of suitably trained personnel capable of developing and implementing competitive chemical technologies. These findings are supported by the current FRIDGE Study. The occupational distribution and skills requirements of the Aroma and Fine Chemical value chain mirror those of the overall chemical industry sector. Typical skills required include: batch processing, small plant operation, product formulation, industrial chemical synthesis etc. The implementation of this value chain will therefore be constrained by the same general skills availability and shortage confronted by this industry sector.

It has been furthermore been reported by the Chieta report 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. The Chieta report also stated that “Flavour” chemists or olfactory experts are almost impossible to recruit in South Africa. This represents another critical gap in South Africa’s capability of meeting this industry requirement.

Stakeholders have identified the lack of skills technology transfer and business management expertise in commercial enterprises and start-ups as a problem in the downstream chemical sector. There are however limited opportunities to learn such skills in the South African industry. One way of addressing this gap is to provide

[11] 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.

graduates with the opportunity to gain expertise at public and private centres of excellence.

2.5.2 Development of a future pipeline of Aroma and Fine Chemicals

It is a necessity for a new producer in the aroma and fine chemicals business 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.

In the case of essential oils, although this is initially an agricultural process, once the volumes of natural oils have increased there will be opportunity to add additional value locally. In the initial stages this will involve simple chemistry, such as for fractionation, but later it may extend to formulations for end use. Natural products need to be researched and tested for quality, toxicity and to be investigated for their unique properties.

For those companies with limited resources this can be a problem. In addition, the latest customised 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.

The commercialization of new chemical processes in South Africa is not efficient. Innovations, patents and technology transfer are not sufficiently rewarded as they are not considered as part of the core functions of academics and researchers at academic institutions.[12] This focus is reflected in the relatively low number of patents per South African scientist. Furthermore, start-up ventures derived from patentable ideas are also at a low level of 2 per 100 patents. This is compared to the international norm of 10 to 15 start-ups for every 100 patents.[13] It is furthermore widely accepted that 9 in 10 SMEs in South Africa fail within the first two years of operation.[14] Intervention is required in respect of SME support.

In this regard, two focused downstream Fine Chemicals Incubators have recently been established. These are the Godisa funded incubator, Chemin in Port Elizabeth, and Sedichem, in Sedibeng. Research conducted by the European Union has concluded that business incubation is one of the leading strategies to enhance the overall survival rates of SMEs. In developing countries, incubation survival rates rank

[12] Draft Emerging Biotechnology Roadmap: Department of Science and Technology: November 2003
[13] National Biotechnology Audit: September 2003
[14] Godisa News: February 2002: Business Incubation " the ultimate way to increase the survival of SMEs"

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 suggest that they are very effective methods of promoting knowledge intensive, new technology-based activities. There is 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.

2.5.3 Support of the Innovation Cycle

The recent 2003 Emerging Biotechnology Roadmap found that there remains a substantial financial gap to bridge the chasm between innovation and commercialization.[15] Funds are limited and the required time frame for obtaining a return on the investment is often too short. The same can be said for the downstream chemical industry.

There are a number of existing financing instruments in South Africa. The general risk averseness on the part of financiers and the lack of appropriate venture capital funders severely hampers the creation of new value chains or new enterprises based on current research. The criteria applied by current sources of funding by their very nature limits funding sources available for research and innovation for new start-up companies, or companies without substantial existing international exposure or indeed even the creation of new value chains based on innovative technologies.

2.6 Overall Conclusions

This Study suggests that South African support of an investment in an Aroma and Fine Chemicals cluster, based on the value chains indicated, would help to bridge the innovation gap identified in the South African national research and development strategy, thereby benefiting the downstream chemical sector. These new value chains could potentially establish a local Aroma and Fine Chemicals platform acting as a springboard for further innovation and industry growth through commercialization of other Aroma Fine Chemicals.

However, a number of interventions will be required to foster the growth of this value chain. This report outlines a number of strategic recommendations in this regard, which would serve to create an appropriate enabling environment in which growth of this South African Aroma and Fine Chemicals industry could be supported.

[15] Draft Emerging Biotechnology Roadmap: Department of Science and Technology: November 2003

PART 1 – EXECUTIVE SUMMARY

3 RECOMMENDATIONS

This section explores the strategic interventions that can be made to foster the growth of an Aroma and Fine Chemical value chain in South Africa and remove the constraints impeding its creation. Recommendations are therefore made for each individual value chain.

Since synthetically and naturally derived Aroma and Find Chemicals feed into similar downstream industries, there are several recommendations that relate to each of the above value chains. These are referred to as "cross-cutting" recommendations. These relate to the creation of a more sophisticated enabling environment, which will ensure that South Africa develops and maintains a position from which it can compete in the international market for Aroma and Fine Chemicals.

3.1 Aroma Chemicals derived from effluent from the Paper and Pulp Industry

Strategic Intervention: To motivate a detailed feasibility study to establish a viable SME Terpene aroma chemicals manufacturing business based on processing a guaranteed minimum supply of crude sulphonated turpentine and a defined technology.

Specific strategic recommendations

1. Hold discussions with potential crude sulphonated turpentine suppliers to ascertain the potential of a guaranteed supply of crude sulphonated turpentine.

2. Initiate technology development to generate more detailed process chemistry and establish process performance & technical data in order to develop a more accurate techno-economic model.

3.2 Aroma Chemicals Derived from Petrochemical Feed stocks

Strategic Intervention: To motivate the establishment of an Aroma and Fine Chemicals platform based on a mixed cresols feedstock, deploying the CSIR and Mbuyu Biotech suite of technologies to produce the portfolio of products identified in this FRIDGE study, comprising the pHB-intermediate, technical and flavour grade pAA, menthol and OMC as the first phase.

Specific strategic recommendations

1. Develop a strategy to elicit interest from prospective investment parties that have the capacity of completing a detailed business feasibility study into launching the Aroma and Fine Chemical platform and developing a detailed implementation strategy. The

investment partner must therefore have the capacity of ensuring that the following are achieved:

- Identify and secure a source of mixed cresol feedstock at a price equivalent to a pure cresol price of no more than $ 1,250 – 1,458/ton.

- Secure the key enabling technologies for the portfolio of products and ensure that all process development is completed and ready for implementation.

- Secure an internationally competitive technology in respect of OMC.

- Define the detailed utility and service requirements for the envisaged complex.

- Identify and select a potential site capable of providing the utility and services requirements at competitive input costs. The site should have the potential for expansion.

- Develop a strategic plan to attract international strategic alliance partners for menthol and OMC by leveraging the fact that the global competitiveness of the technologies and the potential business can be demonstrated.

2. Facilitate the provision of a world-class site; a secure competitive feedstock; well-trained professional staff, thereby increasing the prospect that an international strategic alliance partner/s can be secured by the prospective investment partner.

Strategic Intervention: To motivate the incubation of the smaller volume aroma chemicals as a second phase investment by SMEs by South African downstream processing incubators.

Specific strategic recommendations

1. Develop a strategy for the smaller volume high value aroma chemicals not included in the Aroma and Fine Chemicals platform project as the second phase of investment in expanding the value chain. Use could be made of the relevant sectoral incubators.

3.3 Aroma Chemicals Derived from Essential Oils

The essential oils value chain traverses a couple of industry sectors. The agricultural aspect of the value chain is the primary production platform for essential oils. Therefore, in order to do justice to the whole value chain, recommendations regarding the agricultural component are also presented.

Strategic Intervention: To motivate that the Government adopt a uniform and coordinated approach towards the development and financing of the essential oil industry, including the creation of a joint forum in which to formulate policy and strategy.

Specific strategic recommendations: Agricultural Issues

1. Clarify the role of Governmental Departments (for example, Department of Trade and Industry, Department of Science and Technology and National Department of Agriculture) with respect to their roles in the development and support of the essential oil industry.

2. Clarify the role of Governmental research institutions (for example, the National Botanical Institute, the Agricultural Research Council and the CSIR), with respect to essential oils and determine the manner in which the outputs of their research may be made available to the South African public.

3. Prepare an inventory of all information, relevant to essential oils, housed within government institutions including information relating to indigenous plant materials and their extracts.

4. Create a central database that allows South Africa to manage its knowledge base with regards to essential oils (and other potential non-food crop types) including information relating to the selection of plant material, results of growing trials, studies relating to the economics of essential oil production, chemical composition of plants and their extracts, etc.

5. Consider the development and support of regional producer centres, which will promote a multi-disciplinary approach to essential oil production. These should take advantage of the synergies afforded by the presence of tertiary institutions (producing graduates in agriculture, botany or chemistry and having laboratory facilities), the presence of suitable growing conditions and the presence of committed producers.

6. Consolidate any initiative regarding essential oils into a broader rural industries development strategy. Reference should be made to the experience of other

countries, such as Australia's Rural Industries Research and Development Corporation.

7. Ensure publicly funded research is conducted with a view to determining and setting standards with regards to such factors as (1) the correct geno-types, (2) the correct growing conditions, (3) the correct harvesting and post-harvesting procedures (4) best practice with regards to distillation. Research could be conducted on the basis of public private partnerships where producers become "crop champions" for public research purposes. The results of such research should be publicly available to allow for the expansion of the industry and to promote international confidence in the South African industry. It should also form the basis for the development of skills training and development materials.

8. Establish a national or regional system of plant material banks to ensure that quality plant material is available for local production. This responsibility could be allocated to agricultural colleges and Agricultural Research Council divisions, probably part of the regional producer centres.

9. Develop courses in Good Agricultural Practices, particularly for previously disadvantaged communities, and particularly with regards to good harvesting and post harvesting practices, which can have significant impact on the yields received and the economic viability of the enterprise.

Specific strategic recommendations: Primary Beneficiation

1. Provide technical assistance and training in respect of the operation of distilling equipment, particularly with regards to quality control.

2. Support research into new extraction processes such as super critical fluid extraction with a view of developing a new extraction enabling technology.

3. Conduct research and development work in respect of cost effective "in-field" chemical analysis techniques.

Specific strategic recommendations: Secondary Beneficiation

1. Develop a national system of standards (corresponding to the ISO standards, but adapted where necessary) or a voluntary industry standard, which will promote the production of good quality oils. Standards should relate to the oils themselves and to the testing procedures. This could also include a voluntary certification process.

2. Create a national database for oil profiles and GC "fingerprints". This would be particularly useful in respect of indigenous plant extracts. This should go hand in

hand with the generation of research that would support the registration of products with international regulatory bodies. South Africa could perhaps partner with a large trading partner like the European Union in the development of this competency.

Specific strategic recommendations: Marketing and customer relations

1. Consideration should be given to how best to prepare and publish essential oil production and trade statistics.

2. Develop an appropriate national marketing strategy for the industry.

Specific strategic recommendations: Commercial issues

1. Consult potential funding sources (such as the Landbank and the IDC) in the formulation of policy and strategy for the development of the essential oil industry.

2. Review the existing community projects, supported by government, in order to document the lessons learned and to assess their long-term viability.

3. Consider applying co-operative structures to the development of the essential oils industry, particularly as a vehicle for rural development initiatives as they combined individual initiative with communal support and co-operation.

4. Identify businesses involved in the secondary beneficiation stage for support in regional incubators. These could include businesses involved in the production of both synthetic and naturally derived chemicals.

3.4 Cross-cutting Recommendations

3.4.1 Skills Development

The limited availability of skills has been cited as a constraint to growth in the chemical industry.

Strategic Intervention: To target training interventions by assessing the skills development requirements of existing Aroma Chemical, Essential Oil and Plant Extracts, and Flavour and Fragrance industries.

Specific strategic recommendations

1. Develop learnership programmes with the qualification of specific skills in technical formulation and olfactory related subjects. Olfactory related subjects should also be taught by the higher education institutions at post-graduate level.

2. Encourage learnerships within a 'new' qualification of technical sales, in support of the fine and speciality chemicals sub-sector.

3. Develop a strategic plan whereby existing research organisations and fine chemicals companies could play a pivotal role in the training of technical skills. Technologist exchange programs with the new aroma and fine chemical business could be implemented to train and hone operational skills (by the trainee working on pilot or existing manufacturing plants) and scientific skills (through supplementing technical resource requirements on development projects).

4. Develop training programmes at higher education institutions aimed at furnishing post-graduates with skills targeted at the downstream chemical manufacturing industry. Courses should include aspects of fundamental chemical training, such as industrial chemical synthesis, batch processing, small plant operation, and product formulation. Post-graduate skills with respect to the successful transfer of laboratory procedures into commercially viable production processes should also be taught. These programmes should furthermore include a strong entrepreneurial and business development component, including modules in accounting, business economics, marketing, strategy, management of operations, quality and project management. This will promote the training of numerate graduates with the unique combination of technical as well as management skills.

5. Promote industry-led programmes and networks leading to collaborative efforts between academia and industry. An example is the United Kingdom's BRITEST™ programme. This programme's specific objective is for private companies to participate and provide leadership for projects designed to enhance the industrial relevance of university research and make it more broadly available to industry. The programme focuses on early stages of chemical processes where chemists' ideas are converted into process applications at industrial scale. The outcome of the programme is the innovative development of better approaches for scaling up from test-tube to production plant in the downstream manufacturing industries, thereby improving economic competitiveness. The programme promotes access to creative development in science, engineering and technology, as well has ensuring a continued supply of well-trained scientists and engineers. This interaction will furthermore serve to increase awareness about the skills required and used in the chemical industry.

3.4.2 Development of a Pipeline of Aroma and Fine Chemicals

Aroma and fine chemicals companies are dependant on their ability to create innovative products in order to grow sales, create markets and add value to existing products.

Strategic Intervention: To develop a balanced portfolio of a future pipeline of products.

Specific strategic recommendations

1. Hold discussions with the South African Flavour and Fragrance houses (both local and international) to explore the potential for integration of the nascent aroma and fine chemical industry into their activities. These discussions should identify further opportunities for the manufacture of a pipeline of Aroma Chemicals specifically selected as being relevant for the regional market.

2. Identify technology partner/s for the research and development of a future pipeline of Aroma and Fine Chemicals to this value chain. The partner/s should be research organizations/institutions with specific experience in the field of Aroma and Fine Chemical research and innovation.

3. Consider the promotion of the use of existing pilot plant and small-scale toll manufacture infrastructure to reduce the risk of full-scale dedicated investments by allowing technology testing, scale-up and early market penetration for the Aroma and Fine Chemical business. Such infrastructure will have to comply with current Good Manufacturing Practice. The manufacture of small pilot scale quantities would allow early assessment of the product's ability to meet market needs, and will promote direct customer interaction at an early stage. Furthermore, new products or changes to existing product specifications could rapidly be implemented and tested within the customer's flavour and fragrance formulation or product. The Aroma and Fine Chemical business can therefore meet the requirement of customer responsiveness before a full-scale investment in new capacity is required.

4. Develop a funding programme for research and development into the value adding beneficiation processes of natural products in order to develop niche or value-added products. For example, this could involve research into the process of "splitting" (fractioning) the natural product into its chemical components thereby isolating the pure natural aroma chemical.

5. Fund research into the application of South African indigenous materials in the areas of flavour and fragrances and the complementary areas of cosmetics and

nutraceuticals. The focus should be on identifying the "active ingredients" and determining the general safety of the chemicals for human (and other) use.

6. Develop a strategic plan to incubate the smaller volume aroma chemicals identified and proposed as a second phase investment by the South African Downstream Processing incubators. This process will increase the success rate of the start-up companies and provide some of the skills needs, both business and technical, identified as being critically required by the South African chemical industry.

3.4.3 Support of the innovation cycle

An innovation chasm in the phase between research and development and the commercialisation of viable products has been identified. Overcoming these constraints is critical to ensuring the longer-term sustainability of this industry.

Strategic Intervention: To bridge the innovation chasm between research and development and the commercialisation of viable products.

Specific strategic recommendations

1 Review the funding process for the latter phase of technology innovation i.e. scale-up, product introduction, process engineering, and new plant trials, before projects meet the criteria for private sector investment. This could have a direct impact on stimulating industry demand for research.

2 Involve potential funding sources in the formulation of policy and strategy for the development of the industry. These agencies need to be informed of the dynamics of the industry so that they can properly develop funding packages to meet the needs of the industry. Furthermore, the industry needs to determine what factors need to be in place in order to make the industry more attractive to these institutions.

3.4.4 Integration into the downstream Flavour and Fragrance Industry

Consideration should be given to the development of complementary value chains in the fields of flavour and fragrance formulation, cosmetics and nutraceuticals. These draw heavily on the same skills and experience base.

Strategic Intervention: To begin the process of integrating the Aroma and Fine Chemical value chain into the next stage of the Flavour and Fragrance Industry (Step 2).

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Specific strategic recommendations

1 Promote education and skills development in the downstream flavour and fragrance industry and the complementary industries of cosmetics and nutraceuticals. South African tertiary institutions should therefore provide courses in cosmetics and flavour and fragrance formulation.

2 Develop at least one regional centre of excellence in each of the areas of flavour and fragrances, cosmetics and nutraceuticals. These should take advantage of the synergies afforded by the presence of tertiary institutions (producing graduates in agriculture, botany, chemistry, pharmacology and having laboratory facilities etc.)

APPENDIX "A" - TERMS OF REFERENCE

TERMS OF REFERENCE OF THE STUDY

Aroma Fragrance Fine Chemicals (AFFC) formulations are used globally for imparting attractive taste and aroma to processed foods and beverages and adding pleasing scents to perfumes, toiletries and detergents. The world-wide industry generally earns returns in excess of the chemical industry average. The industry's close association with the health, personal care and food and beverage markets means that its revenues are relatively stable, largely insensitive to commodity cycles and relatively recession-resistant.

The industry can be segmented, broadly, into three areas, namely: (i) natural and synthetic aroma and flavour fine chemicals production, (ii) compounding of these chemicals into formulations tailored to meet specific customer requirements, and (iii) use of the formulations in the production of personal care and pharmaceutical active ingredients.

Certain large international flavour and fragrance houses exist, which specialize in compounding flavour and fragrance chemicals, and which, for historical and strategic reasons, also produce selected aroma and flavour chemicals for captive use. In addition, some also manufacture personal care active ingredients from captive and purchased aroma chemicals.

Success in the formulation and compounding business is dependent on an ability to offer a basket of products, the creativity of flavourists and perfumers, branding and marketing skills, and an ability to respond quickly to ever-changing trends in consumer preference.

Commencing in the late 1980's, AECI Limited had identified certain aroma and flavour fine chemicals, which it believed could form part of a new fine chemicals business that the company wanted to develop. AECI carried out an intensive research and development programme, over a period of more than ten years, aimed at developing competitive manufacturing technologies for selected aroma and flavour fine chemicals.

During 1998, AECI decided to scale down its wide-ranging in-house research and development programme, and outsourced further work on aroma and flavour fine chemical technology development to the CSIR.

Together with the CSIR, AECI developed an AFFC portfolio with the original intention of becoming a leading global producer of selected products, supplying a basket of strategic aroma chemicals to specific flavour and fragrance houses for formulation and compounding. The AECI portfolio was constructed around the synthesis of petrochemical feed stocks.

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During 2001, in line with a wide-ranging business transformation process, AECI took a strategic decision to exit from its fine chemicals development programme, and to offer the know-how and technology, which had been developed, to interested parties. AECI reached agreement with the CSIR during 2003, that AECI would transfer the rights to the range of aroma and flavour fine chemical technologies to the CSIR, in exchange for sharing of the benefits which may arise from licensing or sale of any of the technologies.

The CSIR now owns the technologies in respect of the proposed portfolio of AFFC and the Fund for Research into Industrial Development, Growth and Equity (FRIDGE) proposed a study with the following broad objectives:

- To review the AECI proposed AFFC portfolio for potential commercial development;
- To include a study on the potential use of effluent from the paper and pulp industry as a raw material for AFFC products;
- To include a study on the potential synergy between developing synthetic AFFC production facilities and developing South African natural sources of AFFC.

The products proposed for commercialization by AECI were selected on the basis that they were large volume aroma and flavour chemicals, serve actively growing end-use markets, had low risk of substitution, and did not require lengthy and costly registration processes for product approval.

The technology developed by AECI, and now owned by CSIR, was aimed at producing the following portfolio:

p-Hydroxybenzaldehyde (pHB)	precursor for PAA, Rasberry Ketone, vanillin, ethyl vanillin and 3,4,5-TMB. precursor for pharmaceutical active ingredients
p-Anisaldehyde (pAA)	flavour and fragrance ingredient precursor for p-anisyl alcohol. precursor for sunscreen active ingredients precursor for pharmaceutical active ingredients
Raspberry ketone	flavour and fragrance ingredient
p-Anisyl alcohol	flavour and fragrance ingredient. precursor for pharmaceutical active ingredients
l-Menthyl acetate	flavour and fragrance ingredient
Vanillin	flavour and fragrance ingredient. precursor for pharmaceutical active ingredients
Ethyl vanillin	flavour and fragrance ingredient

3,4,5-Trimethoxybenzaldehyde	precursor for pharmaceutical active ingredients
m-Cresol	feedstock for l-menthol, produced as a co-product of pHB production
Zingerone	flavour and fragrance ingredient

The stated objectives of the study are:

- The study should clearly indicate the following:
  - Labour requirements and number of jobs expected to be created
  - The attractiveness of local manufacture of synthetic aroma, fragrance and flavour chemicals with specific emphasis on the products already identified.
  - The potential and attractiveness of producing specific aroma, fragrance and flavour compounds from indigenous plant material.
- The study should also explore the potential to use effluent from the paper and pulp industry as a raw material for this product stream. In this regard the logistical and location considerations of a manufacturing facility, or facilities, need to be addressed.
- The study should investigate the following aspects of the project:
  - The feasibility of the manufacturing potential products from indigenous plant material and potential markets.
  - The feasibility of supplying potential regional and international markets with synthetic aroma, fragrance and flavour chemicals.
  - Identify potential technology constraints and costs, and research needs and costs.
  - Recommend government interventions that may be required to ensure success of investment projects.
- The study should also analysis present and future economic developments and their implications on the viability of the commercialization of these technologies in an internationally competitive manner. This will include reviewing the capacity, preferred location of a potential business, or businesses, as well as the relevant value chains, and the investment implications of such economic developments to local or international investors.

- The study should recommend the design of an appropriate suite of investment incentives, within the context of the incentives offered by the Government, to improve the attractiveness of an investment in the proposed product portfolio.

MILESTONE DECISIONS DURING THE STUDY

As the Study progressed the following issues arose that required direction to be given by the Study's Counterpart Group:

- The original scope of the Study (per the Request for Tenders) did not include the study of the potential of the menthol technology package. Presumably this was because AECI had already disposed of the technology prior to referring these matters to FRIDGE. The technology currently resides with Mbuyu Biotech, a joint venture involving CSIR. There is a strong relationship between the product and technologies referenced for the Study and the menthol technology package. It was proposed that the Consultant take the menthol potential into account. This was agreed. (Milestone One)

- The original scope of the Study (per the Request for Tenders) as it related to Aroma Chemicals from the by-products of the paper and pulp industry, appeared to have been confined to the production of the chemicals listed (i.e. vanillin and perhaps ethyl-vanillin). This would be produced from Kraft Black Liquor (KBL). The Consultant proposed that Crude Sulphonate Terpentines (CST's) derived from the paper and pulp industry should also be considered as a source for the production of Aroma Chemicals. This was agreed. (Milestone One)

- The original scope of the Study (per the Request for Tenders) did not include the study of the essential oils industry per se (except perhaps in so far as it related to indigenous flora). However, it was identified that essential oils would be the most likely route for the commercial exploitation of indigenous flora and accordingly the Consultant proposed that this important sector be the focus of the investigation into the potential of natural sources of Aroma Chemicals. This approach was agreed. (Milestone One)

- With regards to the Aroma Chemicals derived from petrochemical feed stocks, the Consultant was requested not to focus on specific sources of *meta-para-cresol*, neither to focus on specific industry partners (investors) but to keep the analysis generic. (Milestone Two)

- With regards to essential oils the Consultant was instructed not to focus too much attention on the agricultural issues surrounding essential oil production. This

would be the focus of another study. The Consultant noted that it would not be practical to perform an economic feasibility on a particular essential oil or basket of essential oils as a large component of the feasibility would require consideration of the agricultural costs of production. It was agreed that the Consultant should focus on the broader strategic issues surrounding the development of the essential oils industry and its potential impact on an Aroma Chemicals value chain. (Milestone Three)

- With regards to Aroma Chemicals derived from the paper and pulp industry, the Consultant identified that the tapping of pine forest for gum terpentine could also be a source of material for the production of terpentine derived Aroma Chemicals. It was agreed that this was outside the scope of the current project, but that the Consultant should provide whatever information was readily available to it. (Milestone Four)

PART 1 – EXECUTIVE SUMMARY

APPENDIX "B" - LIST OF CONTACTS

CONTACT DATABASE

IDC co-ordinator	Hloni Monyeki	011-269-3597
CPG Chairperson	Mary Tsatsi	012 428-7959 / Cell 0824640530

Item	Organisation	Contact name	Contact Details	Comments
	Petrochemical			
1	CSIR: Biochemtek	Fanie Marais	0116052310	Several meetings
2	Consultant	Aubrey Parsons	011 726-2376 Cell 083 300 431	Initial meeting
3	AECI	Andre Engelbrecht	011 806 8885	
4	Merisol	Joe Makhoere/Ahmed Karachi	016 960 3733	Initial meeting
6	Chemin Incubator	Joe Kruger	041- 503 6700	Initial meeting
7	SASOL	Herman Berry	Tel: 011 344 0206	Initial Meeting and research assistance
8	Mbuyu Biotech	Paul Abrahams	011 605 2943	Held meeting to discuss menthol project
	Paper and Pulp			
9	CSIR: Biochemtek	Fanie Marais	0116052310	Meetings: documentation and project discussions
10	CSIR: Biochemtek	Michael Barkhysen	0116052310	Initial meeting: vanillin
11	CSIR: Biochemtek	Shavindra Sukdeo	011 605 2174	Initial meeting: vanillin
12	Clive Teubes	Clive Teubes	011 792-4451	Initial meeting; emails
13	Mondi	Ciska Terblanche	035 902 2111	Contact made
14	Mondi	Tony Scheckle	031 304 7837	Meeting held
15	Sappi Lignotech	Craig Hogan ex AECI Project	039 9736 008	Contact made
16	Paul Statham	Ex AECI Vanillin Project	011 709 8985	Contact made
17	Sappi	Kobus Geldehuys	013 734 611	Contact made, amount of CST from Ngodwana
18	Sappi	Chris Davies	011 360 0271	Contact made, Technology Director Sappi
19	Associated Motor Carriers	Mike Hunter: Forest Operations	035 580 7950/082 657 5558	Telephonic discussions
20	Associated Motor Carriers	Arlenee	035 787 7017	Telephonic discussions
21	Industrial Oleochemical Products	Gillian Lee	031 461 3740	Telephonic discussions
	Indigenous Flora and Essential Oils			
22	CSIR: Biochemtek	Fanie Marais	0116052310	Several meetings
23	CSIR: Biochemtek	Marthinus Horak	0128413295	Currently off ill (Met with Vinesh Maharaj)
24	CSIR: Biochemtek	Shavindra Sukdeo	011 605 2174	Initial meeting
25	SAEOPA	Karen Swanepoel	0827858700 Tel 013 753 3064	Several telephone discussions and meeting in April
26	SAEOPA	Willie Alberts	829636142	Meeting in April
27	Biosys	Robin Learmonth	012 841-4025	Several meetings
28	ARC	Kobus Coetsee	021 8085430	Telephone interview (Now Ex-ARC)
29	Flavourcraft	Ryan Ponquett	031 719 0618	
30	Symrise	Johan Esterhuizen (Sales)/ Rudi	011 921 5911	Telephone : Re Local Market
31	Sharon Bolel	Sharon Bolel	011 487 1661	Telephone interview
32	SAAFFI	Michael Gristwood	Tel/Fax: +27 11 447 2757	Initial meeting
33	DEAT	?		Outside of scope
34	Teubes (Pty) Ltd	Clive Teubes	011 792-4451	Several discussions
35	Cranbrook Flavours	Hennie Jooste	011 392-6650	Telephonic interview
36	Giyani Project - Limpopo Province	Vinesh Maharaj	012 841-3295	Initial Meeting/subsequent meetings
37	Chemin Godisa Incubator	Joe Kruger	041- 503 6700	Initial Meeting and several telephone calls
38	SAAFost	Aubrey Parsons	011 726-2376	Initial meeting
39	Firminech	Bruce Perkins	011 653 0700	Telephone call: Re Local Market
40	IFF	Robert Fletcher	011-922-8800	Telephone call: Re Local Market
41	Proctor and Gamble	Denzel Pillay	011-700-5000	Telephone call: Re Local Market
42	Lever Ponds	Robert Waugh	031-571-9600	Telephone call: Re Local Market
43	Quest International SA	Raj Rama	011 613-6211	Meeting re local market
44	Quest International SA	Tony Scott	011 406 8700	Telephone call: Re Local Market
45	Wesgro	Sector Research Section	021 418 6464	Information received
46	Grassroots Natural Products	Norman Collins	023 232 0526	Telephonic interview
47	Cape Organics Producers Association	Eddie Redelinghuys	021 872 5962	
48	George Oils	Pancho Ndabele	011 881 8299	Out of business
49	Ecocert	Ralph Peckover	021 545 0409	Telephonic interview
50	Producer	Kleinste Van Rensburg		Visit
51	Ekuseni Essential oils- Production	Hennie Duplessis	031-712 2656	Visit
52	Ntala - Producer	Hanneke Hibbert	013 753 3839	Visit
53	Ekuseni Essential oils- Marketing	Jean duplessis	082 461 7385	Telephonic interview
54	Producer	Ian Macdonald	832284535	Telephonic interview

55	Producer	Jarrett Peck	332129045	Telephonic interview
56	Producer	Prof Earle Graven	836330149	Telephonic interview
57	Producer	Chris Rumble	832287695	Telephonic interview
58	Bio Africa	Steph	082 534 4807	Telephonic interview
59	Institute of Natural Resources	Myles Mander	033 346 0796	Telephonic interview
60	TRAFFIC (ES Africa)	David Newton	011 486 1102	Telephonic interview
61	Claman	Ronelle Roberts	011 591 2640	Telephonic interview
62	Cape Fynbos Essential oils	Salome van Eerden	028 314 1614	Telephonic interview
63	Natchem Aromatech	Jean Serra	011 452 1760	Telephonic interview
64	University of Potchefstroom	Prof Breedt	018 482 1241	Telephonic interview
65	University of Witwatersrand	Pro Alvaro Viljoen	011 717 2169	Telephonic interview/ Meeting
66	Afriplex		021 872 4976	Telephonic interview
67	Cedara (KZN)	Dr Maria Defiguera	033 355 9156	Telephonic interview
68	Carst&Walker	Uru Maganol	011 359-4800	Telephonic interview
69	Highland Esential Oils	Flippie Pienaar	051 943 0317	Telephonic interview
70	Herbs A Plenty	Elmarie de Bryn	021 874 1684	Telephonic interview
71	National Dept of Agric	Thabo Ramashala	012 3196079/2 / 072357 3845	Initial Meeting
72	DWAF (Irrigation - Walter vd Westhuizer	Gauteng	012 392 1300	Telephone contact
73	DWAF (Irrigation)	National	012 336 8245/8066	Telephone contact
74	DST	Dr Lusunzi	012 317 4330	Telephone contact
75	DST	Geof Mashambye	012 317 4341	meeting arranged
	GENERAL			
76	Antioxidants and Aroma Fine Chemicals	Geoff Blewitt	035 797 6001	Discussion
77	IFEAT (head office UK)	Louise Kopor	Fax no 0944712500965	email
78	Rooibos limited		274822155	Info obtained
79	Proctor & Gamble	Denzel Pillay	011 700 5000	Telephonic interview
80	Lever Ponds	Robert Waugh	031 571 9600	Telephonic interview
81	Johnson& Johnson	Deedee Sampson	043 709 3211	Telephonic interview
82	Beacon	Tom Larkin	031 460 7200	Telephonic interview
83	BAT	Hanro Steenkamp	021 888 3765	Telephonic interview
84	Nestle	Elize - Buyer	011 889 6579	Telephonic interview
85	Adcock Ingram	Judy Dunner	011 971 4559	Telephonic interview
86	MLG Tobacco	Mr Chirag	011 661 5777	Telephonic interview
87	Sara Lee	Mr Horsley	031 719 7111	Telephonic interview