The Changing World of Oleochemicals

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INTRODUCTION

Never before in the history of oleochemicals have the changes been more dramatic than in the last 25 years. Before discussing these developments, I would like first to define the term oleochemicals and basic oleochemicals as used in this paper.

DEFINITIONS

Oleochemicals are generally chemical products derived from animal or vegetable triglycerides, even if they contain elements of petrochemical origin. Basic oleochemicals are fatty acids, fatty alcohols, methyl esters and glycerine (*Figure 1*).

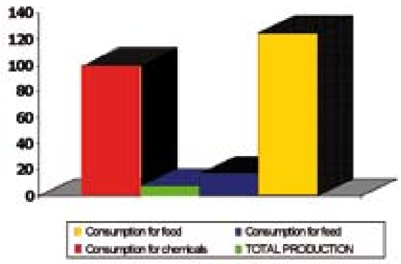

Figure 2. Worldwide production and consumption of oils and fats in 2003 (million tonnes).

RAW MATERIALS FOR BASIC OLEOCHEMICALS

The worldwide production and consumption of fats and oils are shown in *Figure 2*. Although only 14% of the total production of fats and oils is used for oleochemicals, there are some selective triglycerides, like coconut, palm kernel and high erucic rapeseed oil that are mostly so used (*Figure 3*). In the future, the growth of oleochemicals based on these raw materials may be limited by their availability, if the right corrective measures are not taken in time.

MARKETS FOR BASIC OLEOCHEMICALS

Figures 4, 5 and *6* show that basic oleochemicals are used in many different industries. Until a few years ago, methyl esters had only limited use as intermediates for the production of fatty alcohols. With the development of biodiesel in Europe, they have become by far the fastest growing basic oleochemicals.

GLOBAL DEVELOPMENTS IN THE OLEOCHEMICALS INDUSTRY

In this section, the most important developments that have affected the oleochemicals industry in the last 25 years will be discussed.

ASEAN Growth

The rapid growth in production of palm oil and palm kernel oil in ASEAN has made the development

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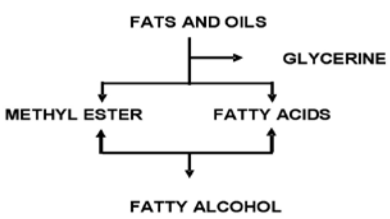

Figure 1. Basic oleochemicals.

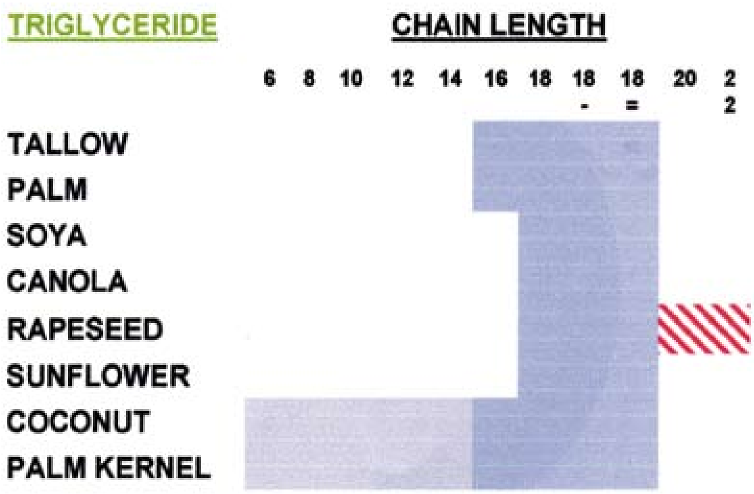

Figure 3. Raw materials for oleochemical.

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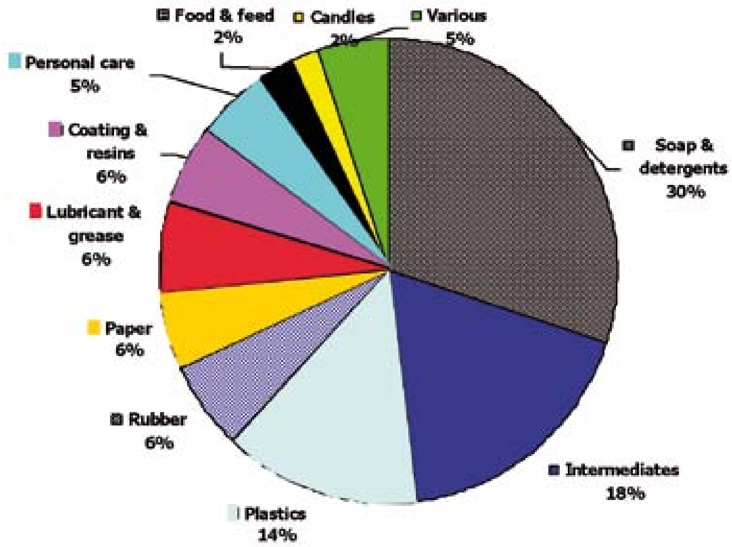

Figure 4. Market for oleochemical - fatty acids.

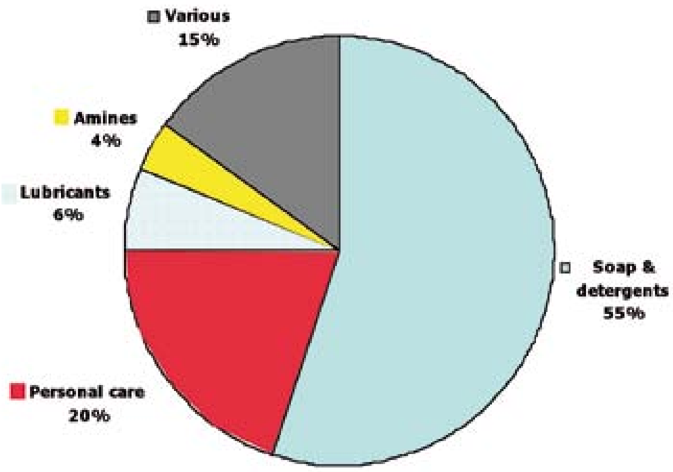

Figure 5. Market for oleochemical - fatty alcohols.

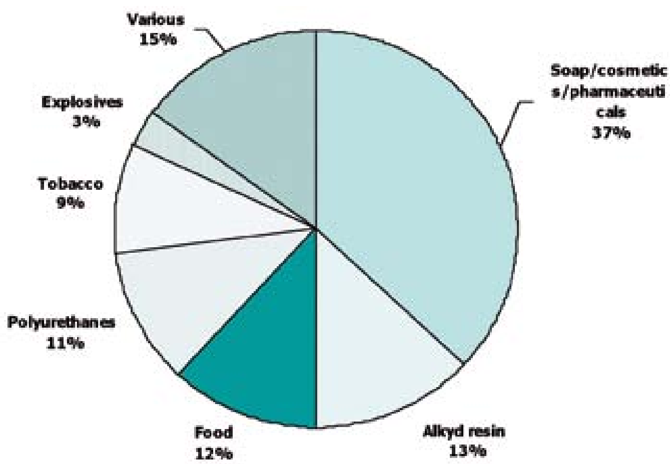

Figure 6. Market for oleochemical - glycerine.

of the oleochemicals industry in this part of the world possible. ASEAN is constantly increasing its world market share of fatty acids and fatty alcohols (*Figures 7* and *8*). Until 2003, the same phenomenon was observed with glycerine. This situation is now changing dramatically, since Europe is strongly increasing the production of glycerine, a co-product of the biodiesel manufacturing process.

Exit of the Traditional Players

Figure 9 shows that the prominent western producers of basic oleochemicals are either selling or limiting their activities in this area. Henkel, Unilever and Petrofina have sold all their oleochemicals activities. Procter & Gamble has closed or sold their fatty acid production plants in the USA, but continues to expand in fatty alcohols and glycerine. Akzo announced the intention to sell its fatty acid activities. From the traditional global companies which developed the oleochemicals industry more than 100 years ago, only Kao Corporation remains fully committed. The driving force behind this exit strategy is in large part the low profitability and the large capital required for world scale operations. Companies like Henkel, Unilever and Procter & Gamble are focusing their activities on consumer goods, a business which in general is less capital intensive and more profitable than basic oleochemicals.

The fast development of oleochemicals production capacity in ASEAN, with its very strong raw material integration, is the most important reason for the drastic reorganization taking place in the global oleochemicals scenario. The increased pressure on margins, coming from modern large scale and highly productive manufacturing units in ASEAN, will continue to influence the global picture. It is only a matter of time until the dominant players in ASEAN look at the possibility of buying the existing production capacity in Europe and the United States.

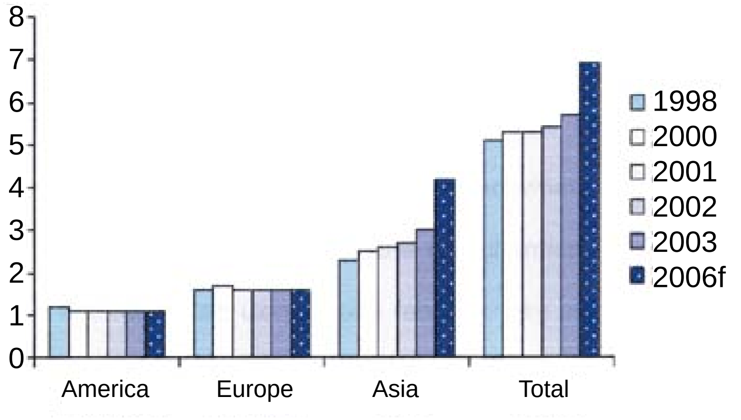

Figure 7. Global fatty acid production capacity (million tonnes).

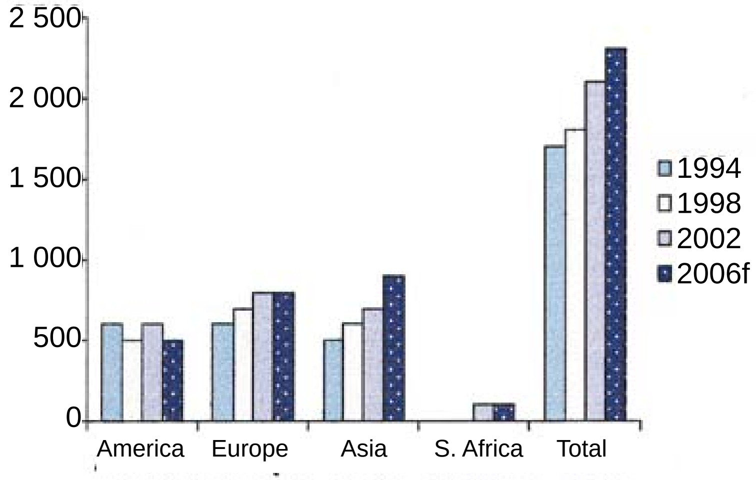

Figure 8. Global fatty acid production capacity - synthetic and natural ('000 tonnes).

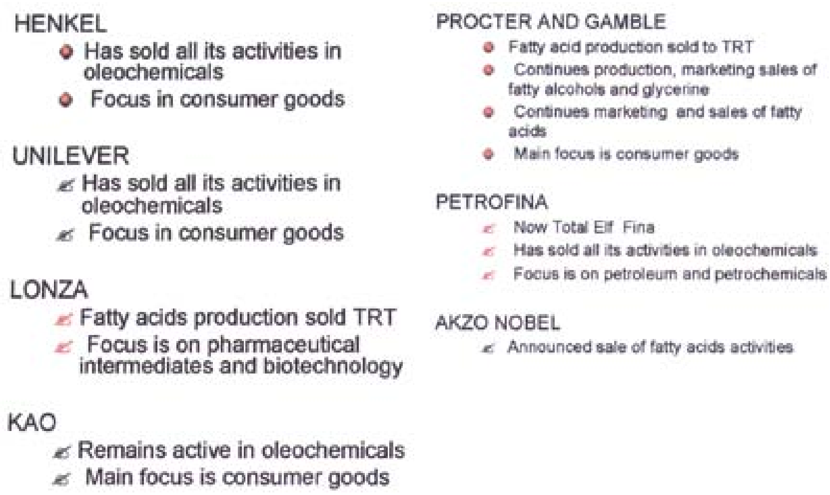

Figure 9. The exit of traditional players.

Consolidation of the Customer Basis

As it is the case in most mature business, the customer basis for basic oleochemicals is also consolidating. *Figure 10* shows some examples of these developments. Smaller companies are acquired by multinational companies which, with their superior purchasing power and global purchasing organizations, are affecting negatively the profitability of the oleochemicals business. On the other hand, this development offers the opportunity for ASEAN producers to enter into direct contact with their customers.

Biodiesel

The European Union (EU), with its effort to support the local farming industry and the aim of developing environmental friendly fuels independent from petroleum, is heavily supporting the production of biodiesel based on canola oil methyl ester (low erucic rapeseed acid methyl ester). Since petroleum diesel has a tax of around € 0.60 per litre, biodiesel, which is not taxed at all, is becoming an attractive business (*Figure 11*). In 2005, the EU will produce more than

2 million tonnes of biodiesel in around 50 production units. The smallest plants produce only a few thousand tonnes, the largest around 200 000 t per year.

While in the past there were few incentives to develop improved processes for the production of methyl esters, new technologies are being developed today to satisfy the demands for environmental friendly biodiesel plants. The process, described in *Figure 12* and used in several large biodiesel plants in Europe, produces only biodiesel, glycerine and powdered potassium sulphate which is sold as fertilizer.

The only advantage that 100% biodiesel made from canola oil offers as fuel is that it is CO_2 neutral (*Figure 13*). In the meantime, most of the biodiesel produced is added to petroleum diesel (up to a maximum of 5%) by the large petroleum companies. The goal of EU is to reduce the tax exemption for biodiesel in a few years. The large budget deficit of Germany and France will probably also place expensive environmental projects on lower priority.

The rapid expansion of biodiesel is affecting negatively the overall profitability of oleochemicals, since it has led to a dramatic reduction in the glycerine margin.

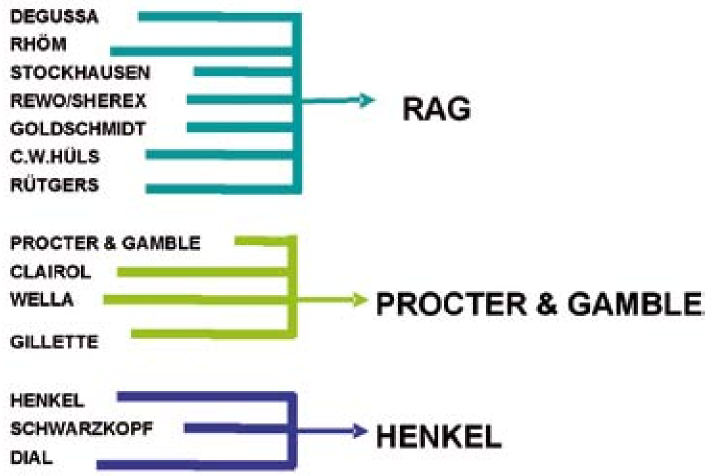

Figure 10. Consolidation of the customer.

Canola Oil + Methanol → Glycerine

↓

Biodiesel

Biodiesel calculation:		**Regular Diesel Cost Calculation:**	
Refined canola	0.55 Euro/l	Diesel cost	0.25 Euro/l
Transesterification	0.05Euro/l		
Tax	0.00 Euro/l	Tax	0.65 Euro/l
Cost of biodiesel	0.60 Euro/l	Cost of regular diesel	0.90 Euro/l
		Selling price of regular diesel	0.95 Euro/l

Figure 11. The success of biodiesel in Europe.

Availability of Manufacturing Technology

With the development of the oleochemicals industry in ASEAN, specialized engineering companies were able to finance the development of competitive manufacturing technology, which originally was only available to the pioneer companies in the USA, Europe and Japan. In some cases, the technology available through the engineering companies today is superior to the technology practiced by the traditional industry leaders. A typical case is the fatty alcohol technology developed by Lurgi (*Figure 14*).

While in the past in general there was only one supplier of technology for a specific process, today there is intensive competition between different engineering companies. An example is fatty alcohols where Lurgi and Davy are offering two different technologies for their production (*Figure 15*). This competition will guarantee that in the future there will be continuous improvement in the technology. The situation in methyl esters production is very similar, where due to the rapid expansion of biodiesel; several companies are offering efficient transesterification technology.

Figure 16 shows the different technologies available for the production of synthetic alcohols which in certain markets, are competing with natural alcohols. The only synthetic alcohols identical to natural alcohols are those made from ethylene and aluminium alkyls by the Ziegler technologies. Since this process

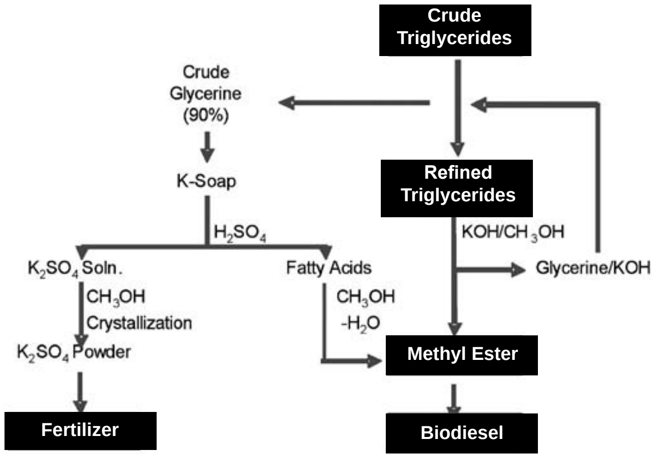

Figure 12. Environment friendly methyl ester process for biodiesel.

is expensive and the intermediate aluminium alkyls difficult to handle, it is highly unlikely that new capacity will be built on this basis.

Preference for Vegetable Oils Over Tallow

Due to the BSE situation in Europe, many uses of tallow have been replaced by vegetable oils. Manufacturers of tallow fatty acids started to produce *vegetable tallow* fatty acid from palm oil or vegetable oleic fatty acid from palm kernel, coconut or canola oil. Although tallow is slowly recovering from its negative image, it is unlikely that it will fully regain the position it had in specific markets, like personal care.

SUPPLY AND DEMAND FOR BASIC OLEOCHEMICALS

The global developments described are having important impacts on the supply and demand of basic oleochemicals.

Fatty Acids

Different sources estimate the global capacity utilization of fatty acid plants at 70% to 75%. Since

+ CO_2 neutral
- 5%-10% less performance than petroleum diesel
- Higher frequency of engine service
- Lower oxidative stability than regular diesel
- Higher frequency of injection pump defects

Figure 13. Used properties of biodiesel 100% canola methyl ester.

1960s	Catalyst:	Slurry
	Raw material:	Fatty acids
1980s	Catalyst:	Fixed bed
	Raw material:	Methyl ester
2000s	Catalyst:	Fixed bed
	Raw material:	Fatty acids

Figure 14. Development of fatty alcohol technology (Lurgi).

NATURAL FATTY ALCOHOLS

Company	Catalyst system	Raw material	Reaction conditions	
Cognis	Fixed	Methyl ester	300 Bar	Trickle phase
P&G	Slurry	Methyl ester	300 Bar	Liquid phase
Kao	Fixed bed	Fatty acids	300 Bar	Trickle phase
Oleon	Fixed bed	Methyl ester	80 Bar	Trickle phase
Davy	Fixed bed	Methyl ester	40 Bar	Gas phase
Lurgi	Slurry	Fatty acids	300 Bar	Liquid phase
Lurgi	Fixed bed	Methyl ester	300 Bar	Trickle phase
Lurgi	Fixed bed	Fatty acids	300 Bar	Trickle phase

Figure 15. Technologies for the production of fatty alcohols.

SYNTHETIC FATTY ALCOHOLS

Co.	Reaction	Catalyst	Raw mat.	Linearity
Shell	Hydroformylation	Cobalt/ Phosphine	Linear olefin	>75%
Shell	Hydroformylation	Cobalt/ Phosphine	Me -branched olefin	Me. branched Alc .
Sasol	Ziegler		Ethylene	100%
Sasol	Hydroformylation	Cobalt	Linear olefin	~50%
Exxon	Hydroformylation	Cobalt	Branched olefin	Multi branched Alc .

COAL- BASED FATTY ALCOHOLS

Co.	Reaction	Catalyst	Raw mat.	Linearity
Sasol	Hydroformylation	Rhodium/ Phosphine	Terminal olefin with 50% branching	50%

Figure 16. Technologies for production of synthetic alcohols.

several new plants are coming on stream in the next few years in Malaysia, Indonesia and China with a total capacity of nearly 500 000 t per year, the situation will not improve. This excess capacity is, as expected, having a negative impact on the profitability of fatty acids (*Figure 17*).

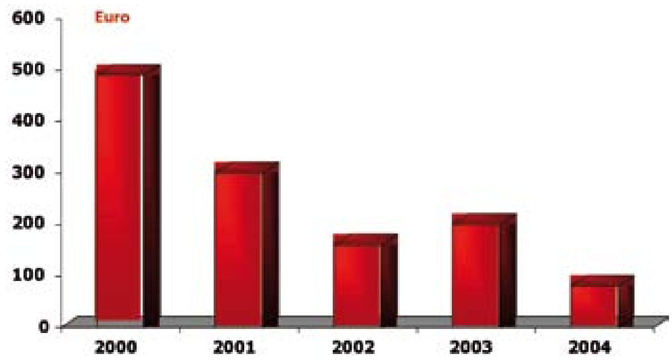

Figure 17. Impact of overcapacity on lauric fatty raw material margin in Europe (Euro per tonne).

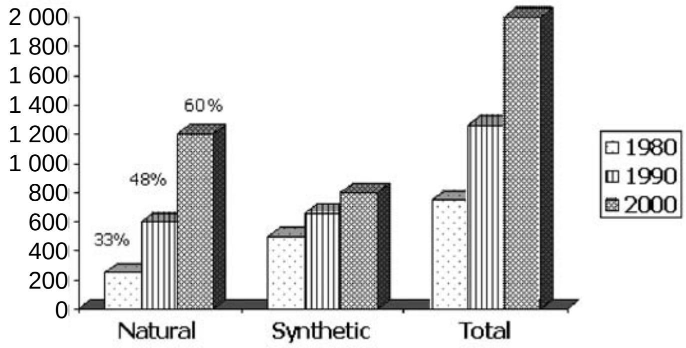

Figure 18. Natural fatty alcohols are growing faster than synthetic alcohol (in '000 t).

Fatty Alcohols

The supply and demand situation for fatty alcohols is much less transparent than that for fatty acids, since long chain alcohols are also made from petrochemicals and coal (*Figure 18*). The synthetic alcohols manufactured via Ziegler technology are identical to natural alcohols, and can replace them in all applications. Those manufactured via hydroformylation technology have a variable degree of branching depending on the catalysts and olefins used, and compete with natural fatty alcohols in some of the largest markets (for example, detergents, dishwashing liquids, *etc*.).

In 2003, the low profitability of fatty alcohols, a result of excess capacity, forced several producers in Europe, the USA and Japan to close inefficient manufacturing units. At this moment, it is estimated that the worldwide supply and demand situation is in equilibrium. Since there are several new fatty alcohol projects under planning or construction (with a total capacity of nearly 400 000 t per year), it is estimated that from the beginning of 2006 there will be again excess capacity.

It is interesting to note that while natural fatty alcohols nearly disappeared from the market before the petroleum crisis in 1974, they have since continuously regained market share at the expense of petrochemically made alcohols. At this moment, it is still too early to forecast the future of synthetic alcohols produced from coal in South Africa.

Glycerine

The world of glycerine was quite in order until biodiesel came about. If the political environment in Europe does not change, we can expect up to 500-700 thousand tonnes of additional glycerine per year from the biodiesel plants within a few years. There will be an outlet for this additional glycerine, but at a low price (*Figure 19*). Experts expect a further decline in the price, in spite of the fact that the petrochemically made polyols are already more expensive than glycerine (for example, ethylene glycol is at around € 1000 per tonne).

This development has had a profound influence on the overall profitability of oleochemicals. A long-term low price of glycerine can also affect other oleochemical processes, since its recovery and purification may not be economically justified. There are already some oleochemical derivatives in the market, like alkanolamides or betaines, which contain glycerine and made directly from triglycerides without going through the fatty acid or methyl ester route. Cognis has also developed a technology to manufacture fatty alcohols through direct hydrogenation of triglycerides, in which glycerine is transformed to propylene glycol.

The search for new uses of glycerine is one of the most urgent areas of innovation in the oleochemicals industry.

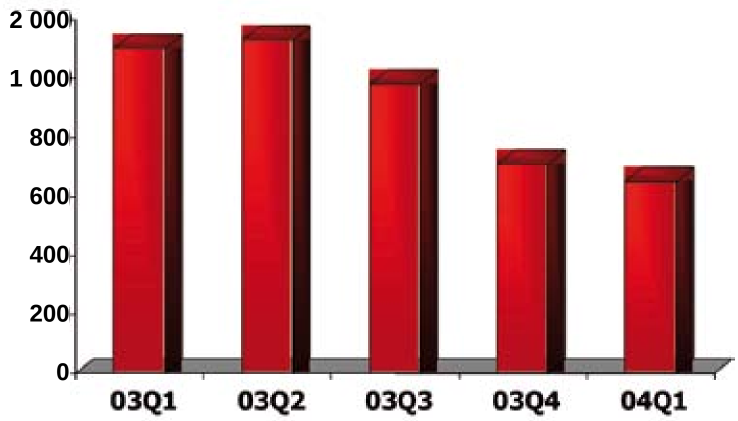

Figure 19. Impact of overcapacity on the selling price of glycerine (in Euro t^{-1}).

100 000	Fatty acids from fats and oils (splitting, fractionation, hydrogenation, glycerine refining) **80 – 100 million**
60 000	Methyl ester from fats and oils distillation **20 – 40 million**
60 000	Fatty alcohols from fatty acids or methyl (hydrogenation, distillation, fractionation, refining) **100 – 120 million**
10 000 t yr^{-1}	Glycerine refining (concentration, distillation, bleaching **10 – 15 million**

Figure 20. Estimated investment cost for world scale plants for producing basic oleochemicals.

INVESTMENT IN WORLD SCALE OLEOCHEMICALS PLANTS

Modern oleochemicals plants are very capital intensive, no matter where they are built. While in the early 1980s, the oleochemicals plants built in ASEAN were relatively small when compared with the plants in Europe or the USA, today the largest and most modern plants are being erected in Malaysia and Indonesia. This modern plants and excellent raw material integration, gives producers in ASEAN an important competitive advantage over their competitors overseas.

Figure 20 shows some examples of the scale of investment made in the last 15 years. As an approximation, it can be said that for a capacity of 100 000 t per year of fatty acid/ glycerine to be made from fats and oils (including infrastructure), an investment of around USD 100 million is required. Due to increased competition between the engineering companies (especially in the area of methyl ester, glycerine and fatty alcohols), there is a tendency for the investment costs to fall.

Investments in basic oleochemicals in ASEAN are very often by palm oil plantations, either alone or with a joint-venture partner, who brings in the technology and a marketing and sales organization. The aim for the plantation is to have an additional market for its palm and palm kernel oils buffered from the price fluctuations in the food market. For example, a plantation which produces around 500 000 t of oil per year, by investing around USD 100 million in fatty acids and glycerine, will still be selling 400 000 t per year of oil in the food market and 100 000 t of oleochemicals.

ALTERNATIVE OLEOCHEMICALS STRATEGIES FOR ASEAN

In view of the existing overcapacity, the low profitability and the large investments required for basic oleochemicals (*Figure 21*), other strategies for growth should be considered.

For companies producing fatty acids, fatty alcohols and glycerine, the most logical growth strategy is to integrate forward into more specialized derivatives. This route is already being taken by several companies, and the production of esters is expanding rapidly in the region.

The main hindrance for the growth of specialties from basic oleochemicals in ASEAN is the fact that the manufacturing know-how is generally not in the hands of the engineering companies which build the plants. These specialties are, generally, from the tonnage point of view, smaller products made in multipurpose batch reactors. Their manufacture is, even in modern manufacturing units, not totally computerized and special attention and intervention from experienced personnel is required during their production processes. Additionally, these products very often cannot just be sold by specifications, like basic oleochemicals, and a specialized applied research and marketing organization is needed.

In view of the high price of lauric oils, more focus should be given to the use of palm oil as raw material for oleochemicals.

A few examples of alternative oleochemicals strategies for ASEAN will be discussed in the following section.

- Large capacity increases in ASEAN have created overcapacity in fatty acids production. Several new projects have been announced
- The capacity increase in ASEAN and European Union has created overcapacity for glycerine. The production of glycerine as a by-product of biodiesel will exacerbate the problem, independent of market demand
- Overcapacity of fatty alcohols can only be avoided by closing the older fatty alcohol plants in the developed countries. New plants under construction or planning will probably again recreate the over capacity
- With continuous capacity increase in basic oleochemicals, lauric oil prices can even increase further
- Capital requirement for cost competitive plants are high
- The profitability of basic oleochemicals, on a stand-alone basis, is not satisfactory

Figure 21. Global situation of basic oleochemicals.

Methyl Ester Sulphonate

The production of methyl ester sulphonate (MES) from palm stearin (*Figure 22*) offers the possibility to replace alkyl benzene sulphonate (worldwide production of over 3 million tonnes per year), the workhorse of the detergent industry. With palm stearin prices below USD 400 per tonne, it should not be a problem to compete with alkyl benzene at more than USD 1000 per tonne. The economic potential of this product class can be seen by the fact that in 2003, an 80 000 t methyl ester sulphonate plant was built in Texas, USA, the last place one would expect a petrochemical product to be replaced by an oleochemical product. The fact that MES is produced as a water-free powdered or flaked solid makes its transport over long distances possible. Therefore, a large scale production unit in a region where the raw materials - palm stearin, methanol, hydrogen, sulphur, hydrogen peroxide and sodium hydroxide are available, will not only satisfy the needs of the local markets, but also allow for export overseas.

Another attractive raw material for the production of MES can be the C16 methyl ester, a by-product from the production of biodiesel of the quality required for European climatic conditions.

Raw Materials for Polymers

Even without investing in large scale plants to produce basic oleochemicals, it is possible to produce specialties directly from palm oil (*Figure 23*). It is possible to produce a broad range of chemicals as intermediates for the polymer industry from epoxidized palm oil. A typical example is polyols, by reacting epoxidized palm oil with ethylene or propylene glycol. The palm oil polyols obtained can be used to replace petrochemical polyols in the manufacture of polyurethanes. The total world market for polyols for polyurethanes is in the range of 5 million tonnes per year, and growing at around 5% per year.

In Europe and the USA, this class of polyols, based on soya oil, is already being used in large scale in the polyurethane industry.

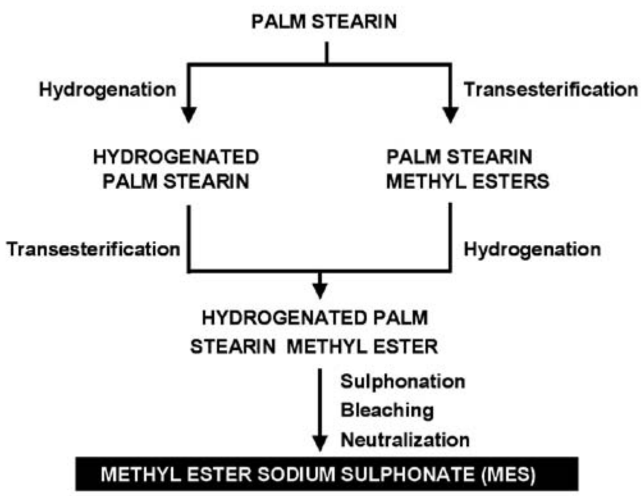

Figure 22. Methyl ester sulphonate from palm stearin.

The epoxidized palm oil itself can be used as a plasticizer for PVC or as extender in rubber.

Nonionic Surfactants from Methyl Esters

Methyl esters of diverse chain lengths are becoming readily available materials since they are produced in large scale and used as biodiesel. Since the biodiesel market is, for the moment, strongly predicated on tax incentives, it is reasonable to develop additional uses for methyl esters. A relatively young technology is their ethoxylation. (*Figure 24*). The products differentiate themselves from fatty alcohol ethoxylates in their foaming behaviour and solubility. They can be produced in conventional ethoxylation units using special catalysts, and their total production cost should be lower than that for fatty alcohol ethoxylates. Especially, the large price difference between unsaturated fatty alcohols and unsaturated methyl esters should make this technology economically very attractive. The only limitations for the use of methyl ester ethoxylates is the reduced hydrolytic stability of the ester bond. On the other hand, several surfactants with similar ester bonds, like esterquats or MES, have found large markets in commercial detergents

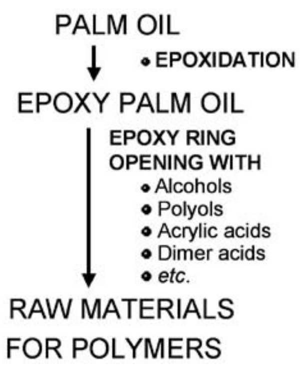

Figure 23. Raw material for polymers from palm oil.

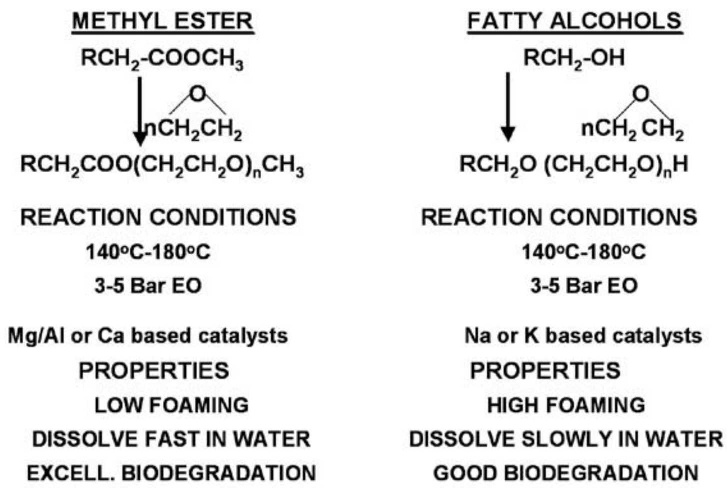

Figure 24. Nonionic surfactants through ethoxylation.

CONCLUSION

The global industry of basic oleochemicals is changing at a dramatic pace. While in Europe, the United States and Japan, the production of fatty acids and fatty alcohols remains constant or is even decreasing, ASEAN, with its strong raw material base, is expanding with world scale plants and increasing rapidly its global market share. In glycerine, even stronger growth is taking place in Europe, where large amounts are produced as co-product in biodiesel production.

The future of biodiesel (canola methyl esters) will depend strongly on the fiscal policies of the EU. With growing fiscal deficits of most of the EU countries, it is very likely that its tax exemption will be reduced step by step.

It can be expected in ASEAN, that the existing producers of basic oleochemicals will gradually direct their future growth to the development of derivates of fatty acids, fatty alcohols, methyl esters and glycerine.

New entrants into the industry should consider other strategies than the production of basic oleochemicals. Opportunities for the development of products from palm and palm kernel oils, without going through basic oleochemicals, should be carefully evaluated.