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Past, present and future in ASEAN

In just four decades, the oleochemical industry in the ASEAN region has grown out of its infancy and developed into a fully functioning sector serving a multitude of applications. Qua Kiat Seng writes

OLEOCHEMICALS ARE COMMONLY USED IN THE PRODUCTION OF SOAPS AND DETERGENTS

Malaysia has a highly successful agricultural industry that has nurtured equally successful downstream processing sectors. The first commercial planting of oil palm took place in 1917 in Tennamaran Estate in Selangor on the west coast of Peninsular Malaysia.

In the 1960s, the pace of oil palm cultivation accelerated, with the Malaysian government encouraging technological improvements to further add value to its exports. One such value addition stream is oleochemicals.

In Malaysia, the first milestone for oleochemical processing was reached in 1979 when the government put science and technology behind the palm oil industry by setting up the Palm Oil Research Institute of Malaysia (PORIM). In 2000, PORIM became the Malaysian Palm Oil Board (MPOB), which was a merger of PORIM and the Palm Oil Registration and Licensing Authority (PORLA).

The first significant oleochemical plant in the Association of Southeast Asian Nations (ASEAN) area was Acidchem in Penang, Malaysia. Its founding was quickly followed by European, Japanese and US producers entering the market.

The Malaysian Oleochemical Manufacturers Group (MOMG) was set up in 1984, followed in 1986 by the Philippines Oleochemical Manufacturers Association (POMA).

The founding of these trade associations made it possible for the ASEAN Oleochemical Manufacturers Group (AOMG) to be formed, comprising MOMG and POMA members and one player from Thailand. Indonesia was a late entrant, but Asosiasi Produsen Oleochemical Indonesia was set up in 1996, adding one more country to AOMG.

From the late 1990s, prominent western producers sold or limited their oleochemicals activities to focus on the more profitable consumer goods business. Akzo, Henkel, Petrofina and Unilever sold their plants, while Procter & Gamble (P&G) closed or sold its fatty acid facilities.

By 2015, the ASEAN area already had excess natural alcohol producing capacity and low oil prices saw manufacturers install new synthetic plants elsewhere using petroleum feedstocks, exacerbating the supply situation..

State of technology

The oleochemical plants that were set up in Malaysia in the 1980s generally had capacities of around 30,000 tonnes/year, making them smaller than similar plants in Europe or the USA. Due to low margins and the drive for larger volumes, producers kept pressing engineering companies towards larger and more modern plants with increasingly efficient technologies.

Due to an increase in competition among plant suppliers, particularly in the area of methyl esters, investments in glycerine and fatty alcohols were falling. By the 2010s, the largest plants had grown in capacity to the region of 150,000-250,000 tonnes/year.

Today a single splitter – a piece of equipment used to separate fatty acids from the feedstock – can reach efficiencies of 600 tonnes/day, operating at 260°C and at pressure of 63 bar, achieving splitting degrees of about 99%.

Such processing efficiencies mark a significant increase from the early days of the ASEAN oleochemicals industry when a splitter would process approximately 150 tonnes/day at a temperature of 250°C and pressure of 52 bar.

The modern technologies consume less high-pressure steam with lower exit temperatures for the split fatty acids and sweetwater. The new splitting columns also foul at a slower pace, facilitating lower maintenance costs.

Technology available today is superior to the technology used by the traditional industry leaders. In the past, there was generally only one supplier of technology for a specific process, but that situation no longer holds today.

The Davy methyl ester processing technology, which converts fatty acids to non-acidic intermediate methyl esters and hydrogenates these to alcohols, is the favoured choice for the ASEAN oleochemical industry today.

However, the older technologies of Henkel, P&G and Kao are still used in some plants, alongside synthetic fatty alcohols technologies using the Ziegler and hydroformulation processes.

FIGURE 1: OLEOCHEMICAL PRODUCT MANUFACTURE ROUTES

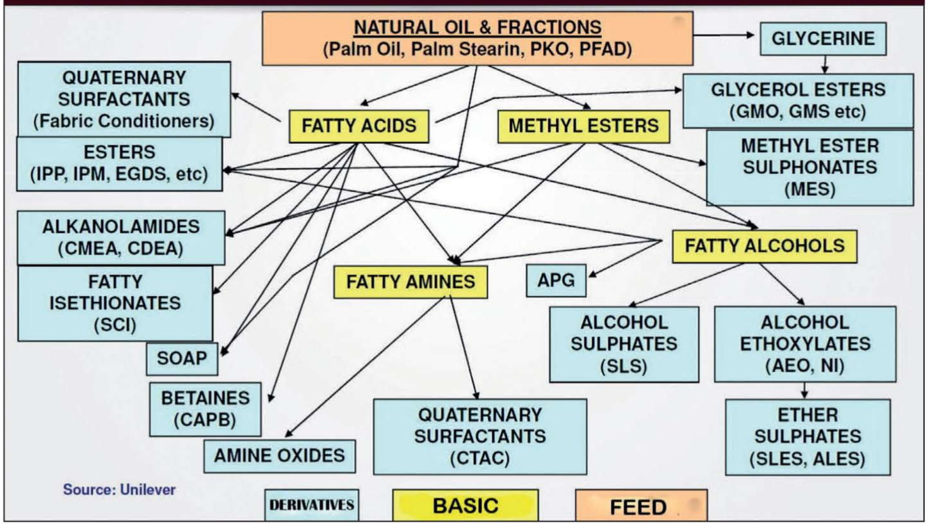
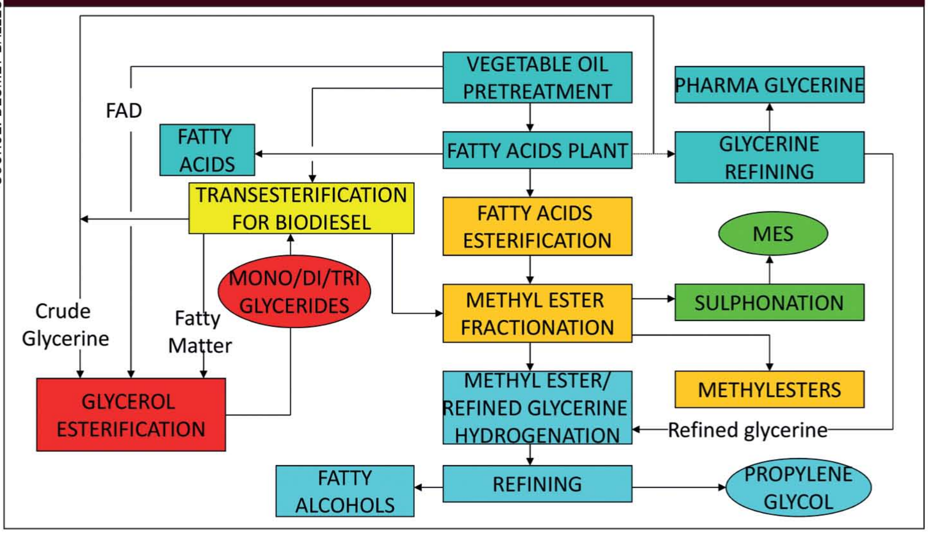


FIGURE 2: MULTIPURPOSE SECOND GENERATION OLEOCHEMICAL PRODUCTION PROCESS

SOURCE: DESMET BALLESTRA



Products and feedstocks

One of the first applications of distilled fatty acids produced by the first ASEAN oleochemical plants in Malaysia was for soap production outside the country. Fatty acids are unstable and do not travel well and the resultant soap was of rather low quality. At the time, even soap made from freshly distilled fatty acids resulted in beige soap with an unpleasant odour.

In 1982, Unichema, an oleochemical company previously owned by Unilever, successfully produced soap noodles that were white and carried no odour, using distilled fatty acids as feedstock. Its soap noodles were, subsequently, the feedstock for Lux soap bars produced by Unilever in Malaysia.

This development opened the door for a new approach to the industry, where the company manufacturing the final soap product focuses only on its own market and uses soap noodles of its specifications, which it makes into soap bars with proprietary additives and production techniques. The messy part of making the raw soap, says Qua, is no longer the producer's responsibility.

This development has received little attention, but it has resulted in an "evergreen market", as the move to liquid soaps takes place only when the annual usage of soap bars exceeds 1kg/person/year.

Apart from soap production, Malaysia got an early start in the biodiesel industry, with the MPOB commencing an R&D project in 1982. Successful field trials were conducted from 1986 to 1994 before the first commercial pilot plant began production in 2000.

In 2008, the Biofuel Industry Act 2007 was passed with a B5 (diesel containing 5% biodiesel) mandate enacted in 2011, B7 in 2014 and B10 in 2016. Indonesia and Thailand, on their parts, have made much more rapid progress.

Many companies in the region are able to offer efficient transesterification technologies with the technology continuously improving to meet ever more stringent standards. With pressure on costs, there is now a move towards cheaper raw materials such as palm fatty acid distillate (PFAD) and used cooking oil (UCO).

Before 1980, tallow and coconut oil were the main raw materials for the oleochemical industry, but after 1980, palm oil and palm kernel oil started to replace them. At the time some end users claimed they could not replace tallow, but after the bovine spongiform encephalopathy (BSE – mad cow disease) outbreak in 2000, more users switched to vegetable oils, including palm oil.

Safety and sustainability

In the 1990s, the oleochemical industry in Malaysia experienced a number of process safety incidents, including a hydrogen generation plant explosion in Malaysia in 1997. The industry's reputation was at an all-time low and players were either uninsurable or had to pay high premiums. As the situation was not sustainable, the industry took a number of steps to address it.

In 1992, the MOMG Technical Committee launched a forum to share and discuss technical issues as well as share process safety best practices. In 2007, the effort was elevated to the ASEAN level with the formation of the AOMG Technical Committee. It has organised annual process safety workshops since 2011, the latest of which – the 7th AOMG Process Safety Workshop – took place on 27-28 July 2017 in Yogyakarta, Indonesia.

The safety situation improved after 1998 with many manufacturers outsourcing their hydrogen gas supply. With the MOMG and AOMG members coming together to share their knowledge from process safety incidents, there have been much fewer and less major accidents.

On the sustainability side, AOMG members hold Rountable on Sustainable Palm Oil (RSPO) supply chain certificates for mass balance (MB) and/or segregated (SG). The AOMG has pushed hard for a physical transition for oleochemicals and helped to draft the rules that were approved in July 2013. MOMG members also have an ongoing life-cycle assessment exercise with the MPOB.

Promising industries

Today, there is growth in end-use industries for oleochemical bioproducts, including in the personal care, surfactants, lubricants and polyols sectors, which drive the demand for bio-based oleochemicals.

These products are often manufactured in biorefineries, facilities that integrate biomass conversion processes and equipment to produce fuel, power, heat and value-added chemicals from biomass. They are analogous to petroleum refineries, which produce multiple fuels and products from petroleum.

An example of a growing oleochemical industry is biolubricants, which benefit from energy saving properties, a high viscosity index, biodegradability and non-toxicity when compared to their petroleum counterparts. They are usually produced from esters with high oleic acid content and, in industrial segments, biolubricants have replaced more than half of petroleum-based lubricants in applications such as drilling, metal working fluids and process oils.

Another growing segment is bioprocess engineering, which focuses on the role of living organisms in the manufacturing process. An example is the enzymatic process used in biodiesel production. As mentioned above, there is an ongoing shift towards using cheaper feedstocks, like UCO and PFAD, with a range of free fatty acids.

For oils, the transesterification catalyst is an alkali, such as sodium methoxide, and for fatty acids the catalyst is an acid, such as paratoluene sulfonic acid (PTSA). As both cannot work together, fatty acids are usually esterified first before undergoing transesterification. Enzymes, for example Novozymes Eversa Transform 2.0, can do both and there are already several plants in operation using enzymes to produce palm biodiesel.

Another example application is yeast fermentation to produce diacids, such as adipic acid. This process was previously based on petroleum, but now uses lauric acid, which Verdezyne – a US synthetic biotech firm – claims helps lower costs and produce less pollutants. Adipic acid is a key component in products such as nylon 6,6.

In the field of second generation biofuels, the Malasyian Economic Transformation Program EPP 7 project promotes bio-oil production through biomass-to-liquid technology.

There are two extraction technologies to produce syngas. A thermochemical conversion and a biochemical conversion. In biochemical conversion, bio-based material is fermented with a unique or genetically modified bacteria. Plants producing biogas in Malaysia and Indonesia could utilise this process, although converting gas-to-liquid to produce biofuels through the Fisher-Tropsch process requires a high energy investment.

Going forward and with the EPP 6 project promoting high-value oleo derivatives and bio-based oleochemicals, metathesis technology can be used to break carbon-carbon double bonds to recombine oleochemical and petrochemical molecules into new di-functional molecules.

There are three product streams for this technology.

- Olefins: 1-decene for co-polymers such as acrylonitrile butadiene styrene (ABS)
- Speciality chemicals: Di-functional products from oleochemicals and petrochemicals in a single molecule, such as 9DDDA (9-dodecenoic acid) that is a key product for nylon 6,12,
- Oleochemicals: C16 and C18 methyl esters for methyl ester sulphonates (MES).

The Elevance Wilmar joint venture biorefinery in Indonesia utilises metathesis technology and has been in operation since 2013, while the Genting Integrated Biorefinery in Malaysia is being commissioned in stages.

A view to the future

The push for bio-products began at the end of 2011 when palm oil and palm kernel prices stopped tracking Brent crude oil prices. Whilst Brent crude prices stayed high at US$100/barrel until the end of 2014, palm oil and palm kernel prices came down, making oleochemical alternatives for petrochemicals attractive, and bringing to the fore new technologies to replace petrochemicals.

Unfortunately, from 2015 the plunge of Brent crude oil to the level of US$50/barrel and the rise of palm oil and palm kernel prices made these new technologies less attractive.

When the first plants were set up in ASEAN, they were designed for a specific purpose, such as producing distilled fatty acids (DFAs) for soap manufacture, fractionation for fatty acid cuts and then adding transesterification leading to fatty alcohols and surfactants.

Going forward, and taking into account market demands, which are also influenced by mandates and crude oil prices, a flexible second generation multi-purpose facility may become the leading trend (*see Figure 2, left*). It could also include an edible oil refinery to supply some of the feed.

Further downstream, when producing high value speciality oleochemicals, there are a number of challenges. The tonnages are lower and the production is carried out in batch reactors.

The know-how does not lie with plant suppliers and production intervention by experienced staff is often needed. Specifications alone are not enough to define the product and there is a need for specialised application research and marketing.

Speciality esters could include product categories such as sorbitan esters, glycol esters, lactate esters, trimethylolpropane (TMP) esters, and others. Owing to their feasible chemical characteristics, glycol esters have witnessed increased demand as emulsifiers in soap, shampoos, and other personal care consumables.

The oleochemical industry began developing in Malaysia barely four decades ago, and there has been unprecedented progress. Nevertheless, many challenges remain, such as overcapacity and low crude oil prices. The industry has shown resilience, however, and process engineering and innovations will continue to overcome some of the issues.

The future of the industry lies in multi-purpose plants and bioprocesses, with the line between oleochemicals and petrochemicals blurring. ●

This article is based on the presentation 'Oleochemicals: Process Engineering & Innovation – Past, Present and Future' made by Qua Kiat Seng of the ASEAN Oleochemical Manufacturers Group at the PIPOC 2017 conference in November 2017